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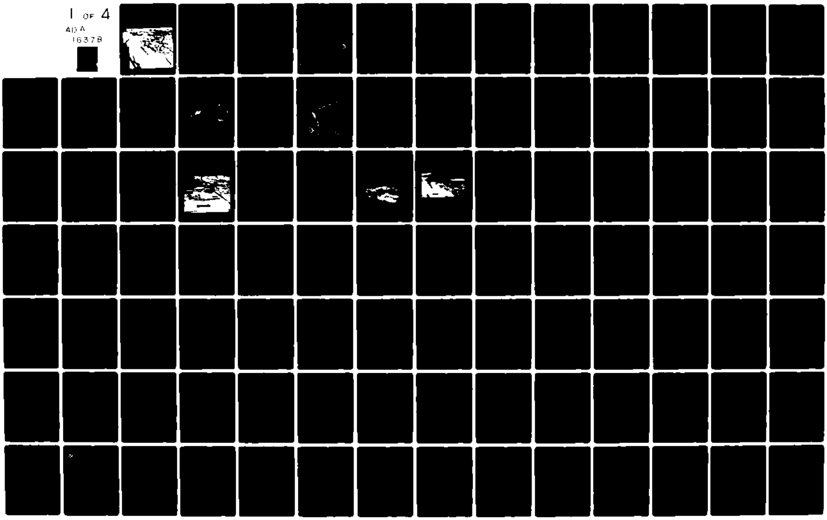

US Army Corps of Engineers
St Paul District

FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA

REEVALUATION OF ST. PAUL FLOOD CONTROL PROJECT

September 1981

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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INDUSTRIAL PARKS

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The St. Paul flood control project was completed in 1964 to protect one of the main industrial areas of the city from flooding of the Mississippi River. Riverview Industrial Park, the area protected by the project, has undergone extensive development ranging from manufacturing plants to commercial establishments and financial institutions. Since development of the project, St. Paul experience major floods in 1965 and 1969, both of which exceeded the previous record flood in 1952. The purpose of this study is to determine

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> the present needs for flood control in the project area and whether the project meets those needs. The specific study area consists of the lands, buildings, and improvements protected by the existing flood barrier. This report contains recommendations on the economic feasibility, environmental acceptability, and advisability of modifying the project or its operation due to changed economic and hydrologic conditions.

(1)

FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA

REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT

ST. PAUL DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1981

SYLLABUS

In 1964 the St. Paul District completed the existing St. Paul Flood Control Project which provides flood barrier protection (levee and floodwall) to 448 previously flood-prone acres along the Mississippi River in St. Paul, Minnesota. The existing project is designed to protect against a flood having a discharge of 168,000 cfs (cubic feet per second). This flood has an exceedence frequency of 0.6 percent or an expected occurrence of once in 167 years. The record flood of 1965 (171,000 cfs) exceeded the project design, and the 1969 flood (156,000 cfs) was within about 1 foot of the project design level. Because of these recent floods and the potential for over $100 million in damages if the flood barrier were to fail or overtop, the St. Paul District was prompted to reevaluate the adequacy of the project and the level of protection it provides.

An intensive investigation in cooperation with city officials, local groups, and State and Federal interests led to development of a plan which optimizes net economic benefits. The District Engineer recommends that the United States participate in this plan which entails a 4-foot barrier raise along the existing project alignment. The Federal first cost of the plan is estimated at $4,889,000, the local first cost at $1,304,000, and the State first cost at $326,000 as outlined by the Administration's cost-sharing policy and subject to certain conditions of local cooperation. The total estimated average annual cost of the proposed improvements is $520,000 and average annual benefits would be about $659,900, yielding a benefit-cost ratio of 1.27.

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INTRODUCTION

STUDY AUTHORITY

Authority for this study is provided by section 216 of the 1970 River and Harbor Act, which states:

> "The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest."

SCOPE OF THE STUDY

The St. Paul flood control project was completed in 1964 to protect one of the main industrial areas of the city from flooding of the Mississippi River. Riverview Industrial Park, the area protected by the project, has undergone extensive development ranging from manufacturing plants to commercial establishments and financial institutions. Since development of the project, St. Paul experienced major floods in 1965 and 1969, both of which exceeded the previous record flood in the area experienced in 1952. The purpose of this study is to determine the present needs for flood control in the project area and whether the project meets those needs. The specific study area consists of the lands, buildings, and improvements protected by the existing flood barrier (see plate 1).

The study includes a review of the design and operation of the completed St. Paul flood control project. Investigations have been made in the detail necessary to assess the feasibility of flood control alternatives evaluated in this report. Alternatives shown to be feasible have been refined in greater technical detail and evaluated further for economic,

environmental, and social acceptability. This report contains recommendations on the economic feasibility, environmental acceptability, and advisability of modifying the project or its operation due to changed economic and hydrologic conditions. A draft environmental assessment has been prepared and incorporated into this report to describe the environmental aspects of proposed measures.

STUDY PARTICIPANTS AND COORDINATION

The study to reevaluate the St. Paul flood control project is a cooperative Federal, State, and local effort. The Corps of Engineers has the principal responsibility for conducting the study, consolidating information and comments from other agencies and local interests, and preparing the report. Agencies and organizations providing assistance include:

Federal

- Coast Guard
- Environmental Protection Agency
- Federal Aviation Administration
- Federal Highway Administration
- Fish and Wildlife Service
- Geological Survey
- National Park Service
- Soil Conservation Service
- Advisory Council on Historic Preservation

State of Minnesota

- Department of Administration
- Department of Agriculture
- Department of Economic Development
- Department of Health
- Department of Natural Resources
- Department of Transportation
- Minnesota State Historic Preservation Office
- Pollution Control Agency
- State Archeologist
- State Planning Agency
- Water Resources Board

City of St. Paul

Department of Finance and Management Services

Department of Public Works

Mayor's Office

Planning and Economic Development Department

Port Authority of St. Paul

Other

American Waterways Operators

Citizens League

Environmental Quality Council

Metropolitan Airports Commission

Metropolitan Council

Metropolitan Waste Control Commission

Minnesota Environmental Control Citizens Association (MECCA)

Minnesota Public Interest Research Group (MPIRG)

Operation 85

Propeller Club

St. Paul Area Chamber of Commerce

St. Paul League of Women Voters

St. Paul Yacht Club

Upper Mississippi Waterways Association

Voice of the Mississippi

West Side Citizens Organization

OTHER STUDIES

Flood problems at and in the vicinity of St. Paul were considered in the following reports for the existing St. Paul flood control project.

a. House Document No. 223, 85th Congress, 1st Session is a survey report dated 23 May 1956. The report considered the needs for flood protection at St. Paul, South St. Paul, Lilydale, the Minneapolis-St. Paul sewage disposal plant, and the South St. Paul sewage disposal plant.

Recommendations included construction of levees, floodwalls, and interior drainage facilities for protection of an area on the right bank of the Mississippi River in St. Paul between river miles 840.2 and 838.3.

b. General Design Memorandum No. 1 on Local Flood Protection for St. Paul and South St. Paul, Minn., Mississippi River, September 1959, defined the hydrologic and hydraulic parameters for the project design.

c. General Design Memorandum No. 2 on Local Flood Protection for St. Paul and South St. Paul, Minnesota, Mississippi River - Project at St. Paul, Minnesota, April 1960, provided for altering the flood barrier alignment to protect an additional 53 acres where industrial expansion occurred after completion of the project document.

THE REPORT AND STUDY PROCESS

This feasibility study has been conducted in three stages. Each stage includes the tasks of problem identification, formulation of alternatives, assessment of impacts, and evaluation. The tasks have been developed in greater detail in each successive stage.

Stage 1 - Plan of Study

Stage 1 concentrated on identification of problems in the study area. During this introductory stage, a wide range of available data was reviewed and an analysis was made of water and related land resource problems and possible solutions. Stage 1 culminated in a plan of study which served as a guide to all Federal, State, and local efforts throughout the study process. The report included a general profile of the study area, description of flood and related problems, presentation of potential solutions to these problems, and discussion of investigations to be conducted in stage 2. The plan of study for review of the St. Paul flood control project was completed in July 1977.

Stage 2 - Development of Intermediate Plans

Stage 2 consisted of data collection, identification of specific problems and problem areas, preliminary formulation of possible alternative solutions identified in the plan of study, and assessment and evaluation of the impacts of the alternatives. At the end of stage 2, only the most feasible alternatives that passed the screening process were recommended for further study. A preliminary feasibility report was prepared to present the findings of stage 2 and recommend whether to proceed with more detailed studies. The stage 2 report for the St. Paul flood control project was completed in September 1978.

Stage 3 - Development of Detailed Plans

Stage 3 further refined the alternatives screened in stage 2 and evaluated impacts in greater detail. Major study efforts involved collection and evaluation of required data, identification of measures which appeared to best solve the problem, and formulation of the optimum scale of development. The feasibility report including the revised draft environmental assessment concludes this stage. The final feasibility report will be submitted to Congress. If an acceptable, economically feasible plan is identified, it will be recommended for detailed design and project construction. However, authorization, advance planning, and funding by Congress are necessary before any recommended measures can be developed. This is the final feasibility report and includes the summation of results of the feasibility investigation.

PROBLEM IDENTIFICATION

NATIONAL OBJECTIVES

In accordance with the Principles and Standards for Planning Water and Related Land Resources (Federal Register, Volume 38, No. 174, Part III, dated 10 September 1973), national economic development and environmental

quality are the two principal planning objectives. This regulation mandates that all federally assisted water resources projects be planned to achieve these national objectives:

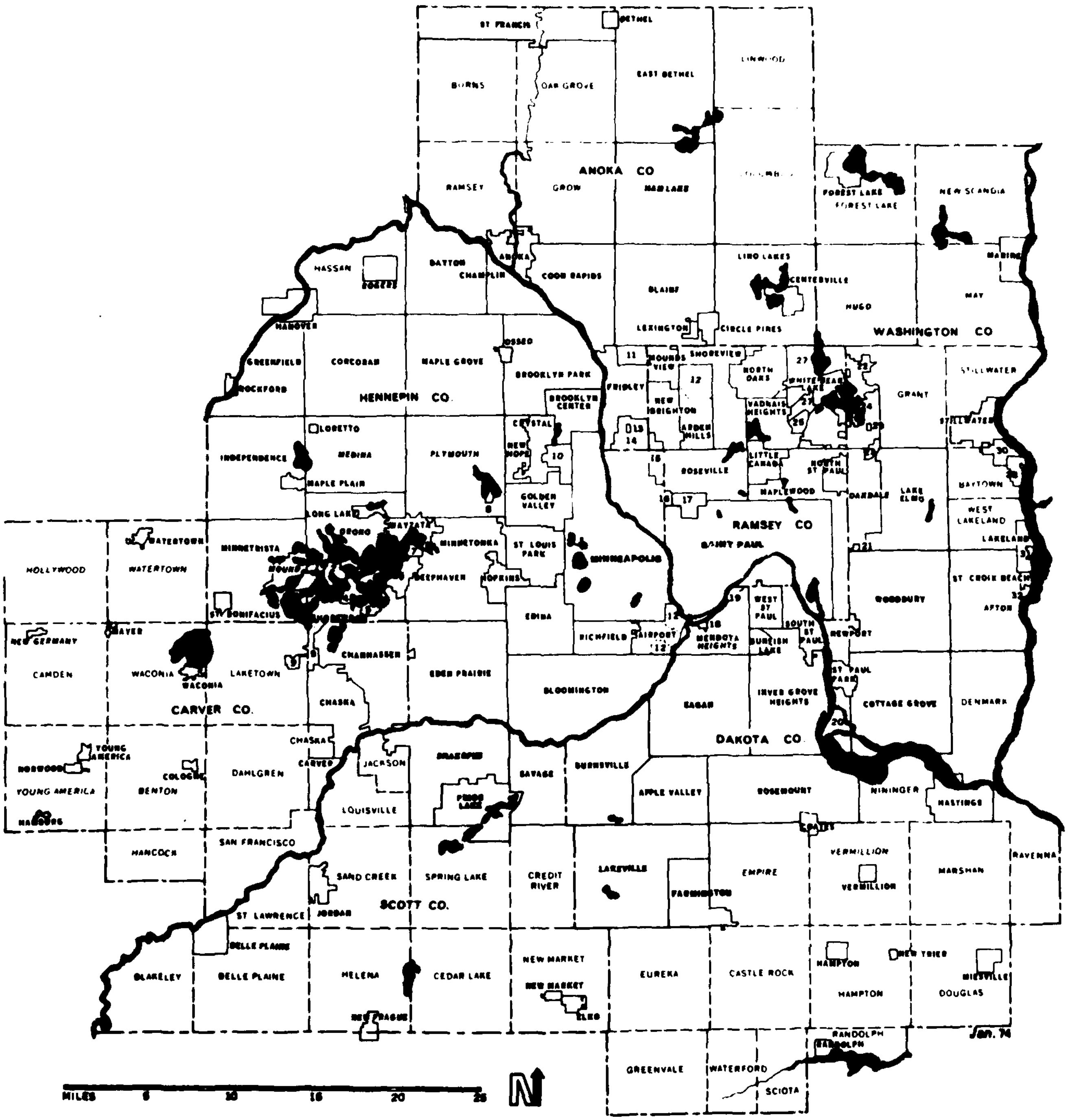
a. National economic development (NED). - Enhance the development of the Nation's economy by increasing the value of output of goods and services and improving national economic efficiency.

b. Environmental quality (EQ). - Enhance the quality of the environment by managing, conserving, preserving, restoring, or improving natural and cultural resources and ecological systems.

The social well-being and regional development accounts are also considered important. Viable alternatives to solve current and prospective water and related land resource problems will be evaluated and examined in light of the goals of increasing national and regional economic gains, enhancing the quality of the environment, and improving social well-being.

EXISTING CONDITIONS - STUDY AREA PROFILE

The Twin Cities metropolitan area consists of 2,968 square miles in east central Minnesota and includes all of Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, and Washington Counties. See the following figure. The area is in the north central part of the Upper Mississippi region and is bordered on the east by the Minnesota-Wisconsin State boundary. Major lakes and rivers account for 147 square miles of surface area and land comprises 2,821 square miles. The area is dominated by the Twin Cities of Minneapolis and St. Paul. St. Paul is the head of commercial navigation on the Federal Mississippi River system and is the hub of commercial transportation networks, barge movements, and transfer and storage of bulk commodities. It is at the confluence of the Mississippi and the Minnesota Rivers and serves as the Upper Midwest's major grain shipment artery. The central business district, situated on the river, brings over 60,000 people in visual and physical contact with the river area daily. The region's



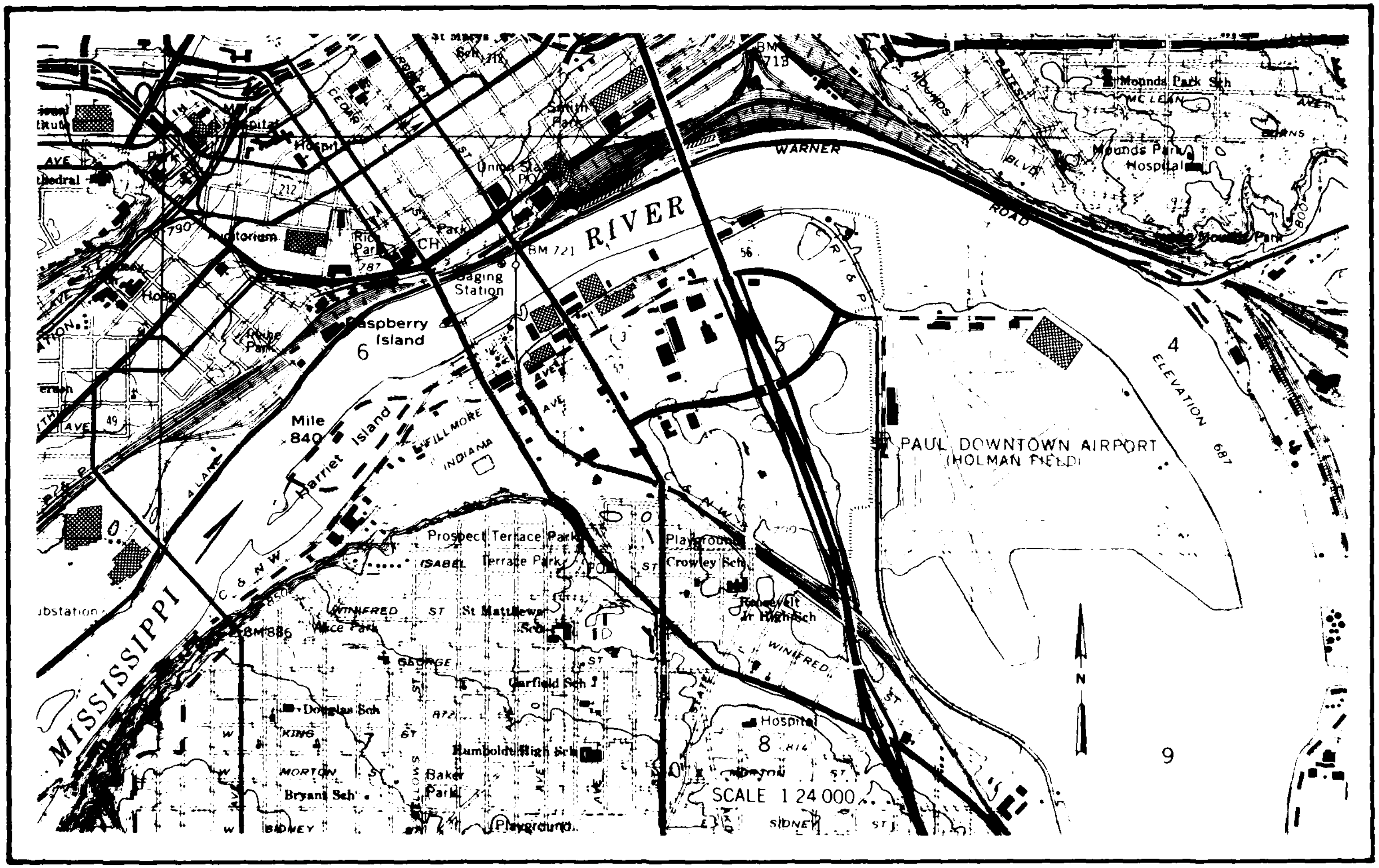
TWIN CITIES METROPOLITAN AREA

second largest airport, serving downtown St. Paul and environs, is located in the floodplain adjacent to the project area. In 1981 there were 134 firms and open space for an additional 17 firms in the area. Most of these firms were constructed after the initial project was completed in 1964.

The units in the project area vary in size from 8.5 acres under one roof for Brown and Bigelow, Inc., to about 500 square feet. The industries represented are warehousing, light manufacturing, heavy industry, services, wholesale, office space, and transportation. The table on page 5-4 shows the distributions both in numbers and percentages. The light manufacturing category has the greatest number of units followed by services and warehousing with 35, 30, and 21 units, respectively. For greater technical detail, refer to appendix 5 "Economic Analysis."

Location

St. Paul is located in Ramsey County in the upper reaches of the Mississippi River between river miles 833.1 and 850.5. The immediate study area is on the Mississippi River directly opposite the downtown area of St. Paul, as shown on the following figure. This location, called the Riverview Industrial Area, is protected by the existing St. Paul flood control project. A variety of firms have built offices, shops, and warehouses in this area because of its convenient central location.



RIVER
MISSISSIPPI
WARNER
ROAD
PAUL DOWNTOWN AIRPORT
(HOLMAN FIELD)
ELEVATION 687
Raspberry Island
Harriet Island
Mile 840
Gaging Station
Mounds Park Sch
Mounds Park Hospital
Prospect Terrace Park
Terrace Park
Crowley Sch
Roosevelt Jr High Sch
St Matthews Sch
Garfield Sch
Douglas Sch
Humboldt High Sch
Baker Park
Bryant Sch
Playground
Hospital
SCALE 1 24 000
WINIFRED
SIDNEY
INDIANA
FILLMORE
MORTON
KING
ISABEL
GEORGE
Auditorium
Union Sta
Smith Park
BM 721
BM 713
BM 886
N
4
5
6
8
9

AREA MAP

Topography

The Mississippi River basin, including the St. Paul area, consists of 36,800 square miles in central and southern Minnesota. Upstream from St. Paul, the basin is gently undulating and varies from broad rolling farmlands in the south to undeveloped areas with many lakes and swamps in the headwaters region.

The Mississippi River flows southeast through Minneapolis and joins with the Minnesota River at Fort Snelling. From here the river flows northeast, makes a wide sweeping bend to the south through St. Paul, and flows southeast to South St. Paul within a valley ranging from 1 to 2 miles wide. Through this reach, the river is bounded by steep bluffs which rise 100 to 200 feet above the valley floor. In the St. Paul area, the river varies in width from 400 to 1,000 feet and has a minimum depth of 9 feet in the navigation channel. The average slope of the river through St. Paul is 0.8 foot per mile.

The metropolitan area features physical variety with rolling glacial moraine interspersed with many lakes and deeply carved ravines and gorges. In addition to three major rivers - the Mississippi, Minnesota, and St. Croix Rivers - the area contains 951 lakes, 200 of which have maximum depths of 10 feet or more. The land surface ranges from less than 700 feet above mean sea level along the floodplains of the Mississippi, Minnesota, and St. Croix Rivers to more than 1,200 feet along the morainic hills in the southern part of the area.

Geology

The present location of the Mississippi River channel was determined by glacial action, and the existing valley was formed by the erosive action of the runoff from the melting glaciers to the north and northwest. After the glaciers retreated and no longer drained the river valley, flows through the St. Paul area were greatly reduced. With the decrease in streamflow,

the river valley was filled with alluvium to depths varying from 50 to 100 feet. Since that time the terraces in the valley have been raised several feet to their present elevations by deposition of alluvial material from the adjacent hillsides. Rock formations exposed in the bluffs along the Mississippi River in the St. Paul area include alternating beds of shale, limestone, and sandstone. These, in turn, are underlain by other limestone and sandstone formations extending to depths of more than 1,000 feet below the surface.

Climate

Because of its location near the geographic center of the continent, the metropolitan area has a predominantly continental climate with mild summers and long, severe winters. Extremes in climatic conditions occur, and abrupt changes in temperature and precipitation are common.

Normal monthly temperatures in St. Paul range from 71.9° F in July to 12.2° F in January. The average annual temperature is approximately 44° F. Recorded daily temperatures range from a high of 108° F in July 1936 to a low of -34° F in January 1936 and January 1970.

Normal monthly precipitation ranges from 3.94 inches in June to 0.73 inch in January. Recorded monthly precipitation extremes vary from a trace in December 1943 to 9.31 inches for August 1977. Normal annual precipitation is approximately 27 inches of which 65 percent occurs from May to September. Recorded annual precipitation ranges from 16.20 inches in 1958 to 39.94 inches in 1965. The mean annual snowfall is 46.5 inches, and 70 percent of the snowfall occurs from December through March. Recorded annual snowfall has ranged from 88.9 inches in 1950-1951 to 14.2 inches in 1930-1931.

Water Supply

The Twin Cities metropolitan area relies on both surface water and groundwater to meet its water supply needs. In 1970, total average water use was 338 mgd (million gallons per day), of which 205 mgd was groundwater and 133 mgd was surface water.

The area has an abundance of surface water including over 120,000 acres of lake surface, 265,000 acres of wetlands, and three major rivers. Surface water drawn from the Mississippi River above Minneapolis serves both the Minneapolis and St. Paul waterworks, and water from the Centerville Lake and Lake Vadnais chain of lakes serves the St. Paul system. Some of the adjoining suburban communities purchase water from the Minneapolis and St. Paul water supply systems. Surface water from the Mississippi, Minnesota, and St. Croix Rivers is also used for cooling water and hydroelectric power generation by four major electric plants and three hydroelectric generating stations in the Twin Cities area.

Many municipalities in the area have developed water supply systems almost entirely from deep wells in bedrock aquifers. Self-supplied industries also use well water. Important groundwater aquifers in the area are the Prairie du Chien-Jordan and the Mount Simon-Hinckley bedrock aquifers. In 1970 these two major aquifers supplied about 175 mgd to the metropolitan area.

The Jordan and overlying Oneota-Shakopee dolomites (Prairie du Chien Group) are the principal groundwater source for municipal and industrial water supply. Yields of 500 gpm (gallons per minute) from wells within the Prairie du Chien-Jordan aquifer are common, with yields as high as 3,000 gpm reported. A report titled "Water Resources Outlook for the Minneapolis-St. Paul Metropolitan Area, 1973" by the Metropolitan Council estimated that the sustained water yield from the Prairie du Chien-Jordan and Mount Simon-Hinckley aquifers within the metropolitan area is about 850 mgd. Of this amount, approximately 375 mgd is recharged from precipitation. The remainder occurs incidentally in the present distribution system, is induced from streams, or is artificially recharged.

Water Quality

The quality of both surface water and groundwater sources in the area is generally good. Groundwater ranges from moderately hard to hard and the water in many of the aquifers has high iron concentrations. Common problems associated with surface water are excessive turbidity, color, coliform organisms, and hardness, although iron and manganese concentrations tend to be lower than those of groundwater.

Total dissolved solids content of groundwater is generally less than the maximum allowable under the U.S. Public Health Service Drinking Water Standards (1962). Local contamination of groundwater has resulted from septic tank, cesspool, and industrial discharges, but this problem has been confined mainly to unconsolidated aquifers and uppermost bedrock aquifers.

Fish and Wildlife

The floodplain forest along the Mississippi River supports a variety of wildlife species. The most common mammals include red fox, raccoon, cottontail rabbit, gray squirrel, skunk, muskrat, and numerous small mammals such as mice, voles, moles, and shrews. The river valley is also the main stem of the Mississippi Flyway, and over 280 bird species have been reported in the Twin Cities metropolitan area.

Because of the extensive industrial development, fish and wildlife resources in the immediate project area are limited. The floodwall areas along the river are nearly devoid of vegetation, with a few trees and grassed levees providing limited habitat for small mammals and birds.

Three endangered species have been identified by the Fish and Wildlife Service as possibly occurring in the project area: American peregrine falcon, Arctic peregrine falcon, and Higgins eye pearly mussel. The peregrine falcon, with a historic breeding range through the United States, has apparently been extirpated from Minnesota. Occasional sitings of the Arctic peregrine falcon may occur during its migration.

The Higgins eye pearly mussel, an uncommon species even early in this century, has become increasingly rare in the Mississippi River. In 1977, the Academy of Natural Sciences of Philadelphia conducted a mussel survey for the Corps of Engineers in pool 2 which includes the project area. The survey revealed that, with the exception of a limited reach in the vicinity of lock and dam 1, no living mussels were present in the muck streambed.

The Fish and Wildlife Service has indicated that the study area is heavily developed, and fish and wildlife resources are limited. Thus, no significant impacts to fish and wildlife are anticipated to result from measures considered in this study.

Recreation

The Recreation Work Group Appendix of the Great River Study (GREAT I) report lists 11 launching lanes, 705 parking spaces, 497 marina slips, 40 rental boats, 24 camping units, and 89 picnic tables in the pool 2 area, which includes the project site. In addition, 45 boats are privately moored in the pool. The Minnesota River portion of pool 2 contributes 2 launching lanes, 125 parking spaces, 60 camping units, 300 picnic tables, 23 miles of hiking trails, and 3.5 miles of cross-country ski trails.

Five parks are adjacent to pool 2:

1. Harriet Island Municipal Park, adjacent to the existing St. Paul Flood Control Project.
2. Hidden Falls Municipal Park.
3. Crosby Lake Municipal Park.
4. Spring Lake County Park.
5. Fort Snelling State Park.

The parks contain almost all of the developed recreation facilities previously mentioned in pool 2. The GREAT I Recreation Work Group Appendix has identified six dredged material island/beach/camps as showing heavy use as indicated by an aerial survey in 1976. Open water recreational boating has been identified by the Recreation Work Group as occurring mostly in the upper and lower portions of pool 2.

Sight-seeing is one of the most prominent recreation activities in the pool 2 area. The GREAT I Recreation Work Group has projected an increase in activity occasions (one person doing one activity) from 140,000 to over 240,000 activity occasions by the year 2025.

Recreation areas directly associated with the project area include Harriet Island Municipal Park and Navy Island. Harriet Island, located across the river from downtown St. Paul, is a 63-acre site currently used for a marina, public boat launch, tour-boat mooring, and picnic and ball field area. A unique aspect of the tour-boat launch is the sternwheeler "Jonathan Padelford," a shallow-draft, steel-hull, excursion boat with a capacity of over 200 passengers. Mounds Park, although not immediately within the project area, commands an excellent view of the Riverview Industrial Area.

Cultural Resources

Navy Island, located in the main channel of the Mississippi River under the Wabasha Street Bridge, is the site of the Minnesota Boat Club facilities. Constructed in 1910, the Minnesota Boat Club building represents the oldest athletic organization in Minnesota. It has been determined eligible for nomination to the National Register of Historic Places.

Navigation

Minneapolis is the head of navigation on the Upper Mississippi River waterway. A system of locks and dams provides a 9-foot navigation channel on the Mississippi River from Minneapolis to the mouth of the Missouri River. On the Minnesota River, a Federal project was completed in 1968 which consisted of deepening the lower 14.7 miles of the river to 9 feet for navigation. Local interests deepened the next 5 miles upstream to a depth of 4 feet. The St. Croix River has been deepened to provide a 9-foot navigation channel for 24 1/2 miles from the mouth at Prescott, Wisconsin, to Stillwater, Minnesota.

Waterborne commerce on the Upper Mississippi River totals over 60 million tons annually, of which more than 15 million tons is received or shipped from the Twin Cities area. Annual waterborne commerce on the Minnesota and St. Croix Rivers amounts to about 5 million and 1 million tons, respectively.

Transportation

The Twin Cities metropolitan area is well supplied by all means of transportation. Two major interstate highways, Interstate 94 and Interstate 35, connect the metropolitan area to outstate areas and adjoining States. In addition, an outer ring of interstate highways encircles the Twin Cities and provides an efficient transportation link between suburban areas. Public transportation is provided by an extensive network of regular and express bus service routes operated by the Metropolitan Transit Commission and smaller private companies. The Twin Cities is also served by six major railroads and an extensive trucking system. Complete air travel facilities are available at the Minneapolis-St. Paul International Airport located about 7 miles southwest of downtown St. Paul. The St. Paul Downtown Airport is used for smaller private and corporate aircraft. Throughout the entire ice-free season, the 9-foot channel project on the Mississippi and Minnesota Rivers provides for river transportation and barge service.

Land Use

Land use in the metropolitan area varies significantly from highly urbanized in Ramsey County, which includes the city of St. Paul, to predominantly rural in Carver and Scott Counties. Overall, cropland constitutes the leading single land use in the seven-county metropolitan area, representing over 40 percent of the total land area. Urban and built-up areas constitute about one-third of the total land use. The following table summarizes land use in the seven-county metropolitan area.

Land area and use[1] - Twin Cities metropolitan area

County	Total land area	Land use: Urban and built-up	Crop	Pasture	Forest	Other
Anoka	425	168	92	7	45	113
Carver	359	27	209	55	41	27
Dakota	571	93	325	33	49	71
Hennepin	564	318	115	34	49	48
Ramsey	160	152	-	-	-	8
Scott	352	42	194	46	41	29
Washington	390	63	203	25	50	49
Total	2,821	863	1,138	200	275	345
Percent of total	100	30.6	40.3	7.1	9.8	12.2

(1) In square miles.
SOURCE: Minneapolis-St. Paul, Water and Land: Future Perspectives and Plans, Upper Mississippi River Basin Commission, 1977.

Human Resources and Economic Development

Population. - St. Paul experienced growth in population from 1940 to 1960. After a peak population of 313,411 in 1960, the population decreased to 309,980 by 1970. Ramsey County and the Minneapolis-St. Paul SMSA (Standard Metropolitan Statistical Area) experienced continued growth from 1940 to 1970. Population data are shown in the following table.

Population, 1940-1970

Location	1940	1950	1960	1970
St. Paul	287,736	311,349	313,411	309,980
Ramsey County	309,935	355,332	422,525	476,255
Minneapolis-St. Paul SMSA[1]	970,367	1,156,556	1,482,030	1,821,718

(1) Includes Ramsey, Washington, Anoka, Hennepin, and Dakota Counties.
SOURCE: Minnesota Census.

Population projections shown in the following table estimate that the population of St. Paul will continue to decline until 1990 and then slowly increase through the year 2030. Ramsey County is expected to experience population growth through 1990 with a continuing gradual decline from 1990 to 2030. The population of the Minneapolis-St. Paul SMSA is projected to continue to increase through 2030.

Population projections, 1980-2030

Location	1980	1990	2000	2010	2020	2030
St. Paul	277,957 (1)	270,000 (1)	275,000 (1)	283,000 (2)	290,000 (2)	298,000 (2)
Ramsey County	485,700 (3)	498,000 (3)	487,000 (3)	485,000 (2)	480,000 (2)	475,000 (2)
Minneapolis-St. Paul SMSA	2,095,000 (4)	2,455,600 (4)	2,760,000 (4)	3,049,000 (2)	3,284,600 (4)	3,503,000 (2)

(1) Metropolitan Council Estimates
(2) Computed estimates.
(3) Minnesota Population Projections, 1970-2000.
(4) OBERS 1972 Projections, Series E, Population.

Per Capita Income. - Per capita income for the Minneapolis-St. Paul SMSA is projected to increase through 2030. As shown in the following table, the per capita income for the Minneapolis-St. Paul SMSA is higher than the per capita income for the United States.

Per capita income - Minneapolis-St. Paul SMSA

Year	Per capita income (1967 dollars)	Relative per capita income (United States = 1.00)
1950	2,517	1.22
1962	3,089	1.19
1970	4,117	1.18
1980	5,600	1.18
1985	6,300	1.17
1990	7,100	1.16
2000	9,200	1.13
2020	14,400	1.09
2030	17,400	1.06 (1)

(1) Extrapolated.
SOURCE: OBERS 1972 Projections, Series E, Population.

Employment. - Employment in Ramsey County increased from 162,437 persons in 1960 to 197,736 persons in 1970, an increase of 21 percent. This compares to an increase of 31 percent for the Minneapolis-St. Paul SMSA. In 1970, employment in manufacturing represented about 27 percent of total employment for Ramsey County, and the households and services category accounted for 26 percent. Wholesale and retail trade represented the third largest category, or 20 percent of total employment. Employment figures for Ramsey County from 1950 to 1970 are shown in the following table.

Employment by industry, Ramsey County, 1950-70

Industry sector	1950		1960		1970	
	Number (1)	Percent of total	Number (1)	Percent of total	Number (2)	Percent of total
Construction	8,017	5.6	8,938	5.5	10,076	5.1
Manufacturing	37,506	26.0	42,330	26.1	52,629	26.6
Transportation, communications and utilities	18,695	13.0	16,963	10.4	16,357	8.3
Wholesale and retail trade	32,088	22.3	30,593	18.8	39,991	20.2
Households and services	27,850	19.4	35,878	22.1	51,111	25.8
Public administration and armed forces	8,709	6.1	9,872	6.1	10,630	5.4
Other (finance, agriculture and mining)	10,853	7.6	17,863	11.0	16,942	8.6
Total	143,718	100.0	162,437	100.0	197,736	100.0

(1) Group Patterns in Employment by County, 1940-50 and 1950-60.
(2) General Social and Economic Characteristics of the Minnesota 1970 Census of Population.

Existing Project

The St. Paul flood control project was authorized for design and construction by the Flood Control Act of 1958. The project consists of a flood barrier about 3 miles long, extending from the upper end of Harriet Island on the west bank of the Mississippi River to a point northwest of the St. Paul Downtown Airport (see plate 1). From here the barrier extends inland to high ground southwest of the airport. The barrier is primarily earth levee except for about one-half mile of noncontinuous floodwall along areas where concentrated industrial development limits space for levees. The project was designed with a freeboard of 2.8 feet to protect against a peak flow of 168,000 cfs (cubic feet per second).

Eight stop log closures and five sandbag closures were built to permit use of roads and railroads during periods of normal water stages. Three pumping plants and about 7,000 feet of interceptor and stormwater sewers were built to pump out seepage and rainwater from behind the barrier.

At the time of project authorization, the area to be protected by the proposed flood barrier was a densely developed industrial and heavy commercial district with a smattering of old homes around the outside. The industrial activity consisted of heavy steel fabrication, paint manufacturing, and food processing. Some of the largest wholesale warehouses in the city, including several railroad warehouses, were located here along with many small retail establishments.

Benefits for the project were based on flood damage prevention (73 percent) and land value enhancement (27 percent). It was assumed that development would occur only on vacant land and that enhancement would occur uniformly over a 20-year period. During construction of the project, the St. Paul Port Authority purchased all property east of Robert Street and began development of the Riverview Industrial Park. The St. Paul Housing and Redevelopment Authority made similar improvements on the west side of Robert Street.

The changes in land use far exceed the estimates on which the project was originally justified. The St. Paul Port Authority, which currently has jurisdiction over the entire protected area, reports an investment of over $41 million in public capital for improvements in the Riverview Industrial Area (see the following photograph). Total assessed evaluation of properties currently exceeds $100 million. Total value of inventories for products and other capital goods and content of buildings is in excess of $247 million. The Riverview Industrial Area is now nearly fully developed, and all vacant developable land is certain to be occupied by 1986, according to the Port Authority. Existing industry in this 448-acre area employs over 5,500 persons and pays taxes of more than $1 million per year.

Industrial development in the area protected by the St. Paul flood control project, July 1981

CONDITIONS IF NO FEDERAL ACTION TAKEN

The impressive commercial and industrial growth that has occurred in the Riverview Industrial Area is expected to continue, barring a highly unlikely disaster, regardless of any action or lack of action from the Federal sector. The area is presently protected to the 0.6-percent chance (167-year) flood so there are no State or local statutes that would impede development in the protected area. It is expected that any rare flood event forecast would immediately activate the construction of added lifts on the existing levees and the installation of temporary flashboards on the floodwall sections of the project as happened in the 1965 and 1969 floods. However, this could lead to an excessive reliance on the security developed by these successful past flood fights.

Several actions have occurred or seem probable regardless of the results of this reevaluation. Any analysis of a "no action" condition will be based on the following assumptions concerning future development:

a. The Riverview Industrial Area will continue to grow, primarily as an industrial development district.

b. Any diversity of development in the Riverview area will consist of support facilities such as restaurants and health clubs.

c. Based on past growth and St. Paul Port Authority expectations, the available vacant land will essentially be fully developed by 1986.

d. Riverfront development plans are now being prepared by the St. Paul River Corridor Task Force to meet the requirement of the critical area designation. These plans, soon to be completed, may contain the following features:

- Expansion of general navigation facilities at Harriet Island Harbor (see plate 1).

- Discontinuance of the truck unloading operation adjacent to a portion of Warner Road located on the bank across the river from the project.

- Realignment of Warner Road to allow green space and a walkway-bicycle path approximately 10 feet in width adjacent to the Mississippi River across the river from the project.

- Realignment of the Warner-Shepard Road, Sibley-Jackson Street intersection to allow service vehicle access and passenger loading facilities at Lambert's Landing across the river from the project.

- Unchanged maintenance of the right bank downstream of Wabasha Street.

e. Operators of the Downtown St. Paul Airport (Holman Field) will expand their capabilities by constructing a major new runway between the existing two.

PROBLEMS, NEEDS, AND OPPORTUNITIES

Flooding

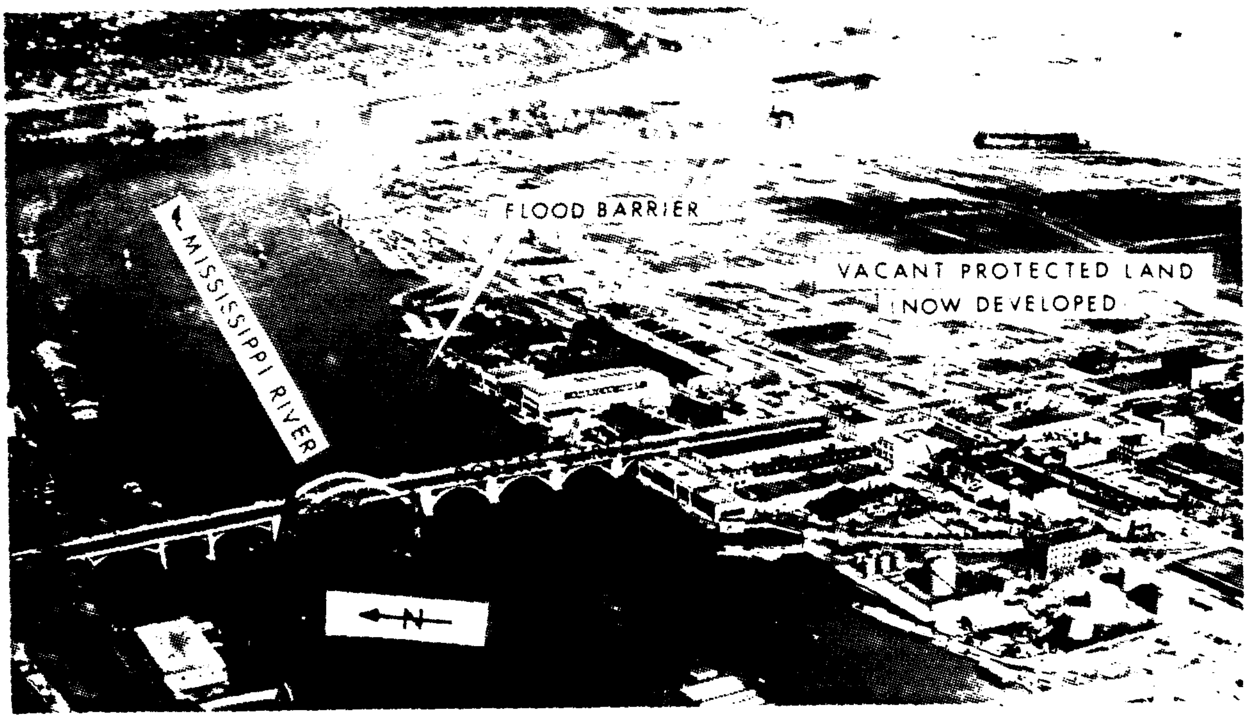
In recent years St. Paul has experienced significant flooding from the Mississippi River. In 1964 the flood barrier project was completed to protect a major industrial area from flooding. The project was designed to provide protection against a discharge of 168,000 cfs with 2.8 feet of freeboard. Since completion of the project, two major floods have occurred which exceeded the previous record flood of 1952, as shown in the following table. The area inundated by the 1952 flood is shown on the following photograph.

Largest Known Floods - Mississippi River at St. Paul, Minnesota

Date	Peak (cfs)	Gage height (feet)
1965	171,000	26.01
1969	156,000	24.52
1952	125,000	22.02
1881	107,000	19.7
1870	104,700	19.4
1951	92,800	18.8
1867	92,000	18.6
1897	86,200	18.0
1875	86,200	18.0
1867	80,800	-
1957	78,400	16.7
1975	78,300	-

St. Paul during the crest of the 1952 flood

1965 Flood. - Late fall rains followed by freezing temperatures and deep frost penetration set the stage for the 1965 flood. Although the snowfall over the winter was normal, it was followed by rains which froze and remained suspended in the snowpack. Most critical, the Mississippi River crest of 80,000 cfs and the Minnesota River crest of 93,000 cfs converged at St. Paul and resulted in the record 171,000-cfs discharge (see the following photograph).



Protected area, 15 April 1965

The city of St. Paul constructed extensive emergency works on the left bank of the river opposite the project, installed flashboards on the floodwall sections of the project, and placed additional fill on the top of the levee sections. Although the 1965 flood flows exceeded the design stage of the project, they were contained within the project freeboard. Heavy seepage

occurred in the extreme western portion of the project where the levee was tied into previously placed fill. This portion of the levee was removed and reconstructed during the 1966 construction season.

The project is credited with preventing $10 million in damages to the industrial area on the right bank of the Mississippi River. Emergency works protected an area on the left bank and prevented $7.8 million in damages. Many areas of the city could not be protected, and over $4 million in urban damages was sustained. Damages to the city utility systems were especially high.

1969 Flood. - In 1968, heavy rains occurred from August through October causing unusual flooding in many areas, particularly along the Minnesota River above the Twin Cities. The ground remained wet through November and froze to form an impervious surface. Record to near-record amounts of snow fell over the north central part of the country during the winter of 1968-1969, and large amounts of snow drifted into low areas such as the valleys of major tributaries in Minnesota.

The 1969 flood fight was well coordinated and efficient. As in 1965, temporary dikes and flashboards were installed on the left bank of the Mississippi River along Shepard and Warner Roads. The project functioned well and no added precautions were required. Within the protected area, considerable seepage occurred but was kept under control. Damages prevented in 1969 by the St. Paul flood control project total about $15 million.

Improvements Desired

The city of St. Paul is concerned with riverfront development. The existing St. Paul project protects new development valued at over $41 million in public capital in addition to much higher private investments. Even with the advanced flood warning techniques available, a theoretical flood in excess of the project's capacity would result in catastrophic damages that would extend to other areas of the city's economic life. Existing industry in the protected area employs well over 5,500 persons, and many of the business units are essential to the operation of other units

in the production chain. The city considers a reevaluation of the existing project to be a necessary undertaking that is especially timely now when the city is evaluating its use of the river and the river corridor.

PLANNING CONSTRAINTS

Any possible resource management plan proposed for the area protected by the St. Paul project must be technically and economically sound, socially and environmentally acceptable, and capable of implementation. The commercial development occurring in recent years is an important limiting factor to any possible changes or improvements that could be proposed for the area. Most options that would increase the degree of protection also require additional lands over and above those already committed to project purposes. Several recently constructed substantial buildings that depend on the existing project for total flood protection are constructed very close to the levee. Any landward increase in levee widths would be difficult to implement without affecting the buildings. Another significant planning restraint consists of the railroad tracks that feed into the area through the levees. The original construction required six railroad closures, and the levee has tracks immediately adjacent to both the landward and river sides for 2,000 feet. Also, any nonstructural or flood proofing measures would be redundant since the project has already successfully protected the area from the maximum flood of record.

Finally, the authority for this section 216 reevaluation study limits the area of consideration solely to that protected by the original project. Any other water related resource options outside the project area would have to be addressed by a separate study.

PLANNING OBJECTIVES

Since completion of construction of the project in 1964, two major floods occurred that substantially exceeded the largest known flood of record. Also, the strategic location adjacent to the downtown area of St. Paul has encouraged commercial development far in excess of that contemplated in the original project report. Based on these existing and probable future conditions and the discussion previously presented under

"Problems, Needs, and Opportunities," the local planning objective has been promulgated as follows: contribute to the existing St. Paul project area by reviewing the suitability of all applicable structural and nonstructural alternatives including modification to the existing project with a view toward providing an additional level of protection that would minimize possible future damages for the Riverview Industrial Area if adequate protection is not now provided.

FORMULATION OF PRELIMINARY PLANS

The purpose of the formulation of preliminary plans is to identify and evaluate alternative measures for accomplishing the national and local planning objectives. In turn, these objectives are derived from problems identified for the area and from Federal, State, and local laws and regulations.

MANAGEMENT MEASURES

During the feasibility study, the following management measures for flood damage reduction were considered separately and in combination.

No Action

This option includes several measures that do not require construction. Significant among these are (1) flood insurance, (2) floodplain regulation, and (3) flood warning provided by the National Weather Service to allow emergency evacuation and limited flood protection measures.

Nonstructural Measures

The word "nonstructural" has been used for many years as an antonym to the word "structural" to describe alternatives to traditional Corps of Engineers projects such as dams, flood barriers, diversions, and channel

modifications. Whereas structural measures act on river or tidal waters to change their direction, area of inundation, volume, stage, or timing, nonstructural measures do not. Nonstructural measures which reduce flood losses can be considered to fall into the following categories:

a. Flood proofing. - This option eliminates the hazard or reduces the vulnerability to flooding through such measures as elevating existing buildings or constructing the habitable portions of new buildings above possible flood levels. Also included are raising damageable utilities and providing watertight barriers through the incorporation of waterproofing, floodwalls, or ring levees.

b. Permanent floodplain evacuation. - The application of this management measure would remove all improvements susceptible to damage by flood action. It would also prevent any additional new construction within the floodplain.

Structural Measures

Physical changes to channels, levees, flood barriers, and similar water-oriented actions constitute the traditional structural measures. Among these are the following:

a. Channel modification. - The changing of channel configuration, usually by enlarging, allows increased channel capacity to be developed.

b. Levees and floodwalls. - The provision of protective barriers to separate the flood prone areas from the flood flows is included under this option.

c. Diversion. - Consideration is given to the transfer of part of the excessive flows to an alternate channel.

d. Flood storage. - Excess flows are temporarily stored for more gradual release.

PLAN FORMULATION RATIONALE

Plans should be formulated to maximize the number of planning objectives that are favorably addressed. Sufficient information on each plan must be developed and discussed so the plans can be compared and evaluated. Criteria were considered under three main categories.

a. Technical criteria consist of appropriate and recognized engineering standards for the design and effectiveness of various alternatives. Each alternative must be "buildable" and have incorporated measures to prevent structural failure.

b. Economic criteria basically consist of benefit and cost comparisons to a common base so each alternative can be equally compared. Attaining maximum net economic benefits is recognized as desirable (i.e., benefits minus costs should be maximized for each alternative). Often benefits occur on an annual basis whereas costs occur principally during project construction. Costs and benefits were annualized to form a basis of comparison. To annualize costs and benefits, an interest rate of 7 3/8 percent, price levels and conditions existing in July 1981, and a 100-year amortization schedule were used.

c. Environmental and other considerations dictate that a selected plan minimize objectionable environmental effects and maximize environmental enhancement potential before, during, and following construction.

In keeping with these criteria, stage 3 studies evaluated alternatives with environmental awareness, screening out alternatives with obvious and overriding adverse environmental impacts, and minimizing, where possible, adverse environmental effects of alternatives recommended for further study.

PLANS OF OTHERS

Much of the underutilized land within the St. Paul flood control project area was purchased by either the St. Paul Port Authority or the St. Paul Housing and Redevelopment Authority and consolidated into tracts suitable

for industrial development. As a result of these city plans, the area is moving forward as an industrial park. The plans of the Port Authority have progressed so effectively that almost all land is sold, leased, or under option. The Port Authority's plans and those provided by private developers reflect that industrial park development will be achieved by 1986.

The St. Paul Department of Planning and Economic Development has a draft plan entitled "The St. Paul Mississippi River Corridor Plan" which was developed under the President's National Investment Strategy. Department representatives are working with regional, State, and Federal agencies in addressing the problems which exist within the river corridor and are providing comprehensive planning that will preserve the natural, scenic, recreational, and economic functions of the river. This overall plan is divided into a number of individual site plans, one of which is the Harriet Island Development Area located at the upper end of the project (see plate 1). This plan proposes to upgrade the recreation areas of Harriet and Navy Islands on the riverward side of the project and introduce new housing units immediately landward of the project. Commercial and retail space would also be constructed adjacent to Wabasha Street. One unique aspect of the plan is the proposal to return Harriet Island to true island status by dredging a channel between the two boat harbors. These plans being formulated by the city are still in the conceptual stage, and several meetings have been held to explore the areas where possible conflicts may exist. At present, the city's plan infringes on portions of the levee project right-of-way and would affect many of the current uses of the park and marina. This problem is being addressed with the formulation of some optional concepts by the city of St. Paul. All possibilities for cooperation between the city, local interests and the Corps in regard to implementation of these two overlapping plans are being explored.

The Federal Highway Administration has a program to construct a scenic parkway the entire length of the Mississippi River. This parkway, known as the Great River Road, is presently planned to be located along the bank opposite the project. Thus, it is expected to have no direct effect on the flood control project.

A parkway is being planned as part of a regional park which will extend upstream from the upper end of the present flood control project. This feature will be included in the overall River Corridor Plan.

ANALYSIS OF PLANS CONSIDERED IN PRELIMINARY PLANNING (STAGES 1 AND 2)

Flood damage reduction solutions considered in this study pertain to measures needed to insure effectiveness of the existing project and an acceptable level of flood protection for the industry located within the protected area. Both structural and nonstructural options have been considered. The no action alternative is generally considered a base from which to measure the desirability or feasibility of the impacts of positive alternative solutions.

In analyzing nonstructural alternatives for this study, the existing flood barriers were considered to remain in place. As the barriers provide a high level of protection, any additional protection which could be provided by nonstructural measures must first duplicate protection up to the existing project design level. In other words, the barrier would be protecting an area in which damageable property had been removed or individually protected or where losses had been insured.

Description of Alternatives

No Action (Alternative 1). - Consideration was given to maintaining the status quo or recommending that no action be taken to raise the degree of protection provided by the existing project. This alternative constitutes the base condition from which performance of other alternatives was measured.

To do nothing would not burden local interests and the Federal Government with the financial costs associated with other alternatives. Nevertheless, average annual damages estimated at over $604,000 for current conditions and $825,100 annually for 1986 fully developed (base year) conditions would remain. These damages would be a significant social and economic burden.

Because the area is currently considered protected to approximately the 167-year flood level, continued development is not restricted by either State law or local ordinances. However, the area is mapped as being within the 500-year floodplain on the city's flood insurance rate map which places it in the "Secondary Flood Hazard Area" category of the State Building Code's flood proofing standards. Because the city enforces the code, some special requirements for future development in the area are related to flooding hazards. Barring a highly unlikely disaster, the Riverview Industrial Area is expected to grow and flourish. All parcels now undeveloped are expected to be developed within 5 years. Provisions for protection from major and rare floods on the Mississippi River would depend on construction of emergency levees over existing levees and placement of flashboards on existing floodwalls.

Floods on the Mississippi River in St. Paul are slow rising and can be predicted. As evidenced by the successful flood fight in 1965 when only minor damages were sustained even though the project design level was surpassed, emergency measures can be quite effective. Reliance on emergency measures can be hazardous, however, especially where a sense of security has developed because of past successful flood fights. Should emergency measures fail, damages estimated at over $100 million would occur.

<u>Removal of Existing Structures (Alternative 2)</u>. - This method of solving flood problems is effective in some limited situations because it removes the structure from the affected area.

The Riverview Industrial Area is composed mainly of commercial and industrial buildings which, because of their size and type of construction (masonry with slab on grade floors), are not feasible to move. Rather than trying to move the structures, it would be more desirable to move the contents to a new facility in a flood free location and tear down the existing structure or use it for some other purpose. There is no apparent use, however, for abandoned floodplain buildings and therefore the option of tearing them down appears most practical.

The cost of forced relocation of the businesses and industries could conservatively be estimated to exceed $130 million, whereas capitalized flood damages prevented by such an action would be less than $13.0 million. Obviously, removal of structures from the Riverview area is not economically feasible. The city of St. Paul does not support this alternative because the more than 130 businesses in the Riverview area provide valuable city tax revenues and provide jobs for over 5,500 area persons. In addition, many local businesses depend on output from Riverview businesses and, as such, they are a vital link in the production chain. Were the relocation forced, many businesses would likely move out of the city and possibly out of the State.

Individually Protecting Structures (Alternative 3). - This method of flood protection is most effective in areas of light flooding and is best applied during original construction.

Individual protection for structures in the Riverview area could be achieved by waterproofing or flood proofing, building ring-like barrier protection, or physically raising structures. Flood proofing all existing buildings is not possible because many existing structures are not designed to withstand high lateral pressures of flooding. This plan of raising flood prone structures several feet where physically possible, removing structures which are not feasible to waterproof or raise, and/or building a levee or floodwall to protect other buildings would entail costs estimated at $65 million. Annualized benefits would amount to $800,000. The benefit-cost ratio would be 0.17.

Flood Insurance and Floodplain Regulation (Alternative 4). - Flood insurance provides assistance to affected property owners through reimbusement for flood damage losses. Floodplain regulation provides an effective method of limiting future damages through restrictions on floodplain development.

The Riverview Industrial Area is currently considered to be removed from the floodplain or flood hazard area because the St. Paul project is considered effective under State and local laws. Since the area is considered

protected to above the 100-year level, floodplain regulations do not apply and flood insurance is not held by or required for industries or businesses in the area. For these reasons, floodplain regulation is not a realistic alternative. The remaining 42 acres of vacant land in the Riverview area will be developed by the base year 1986.

Flood insurance could be purchased by existing industries. Flood insurance does not prevent flood damages but only assists in reimbursing affected property owners for losses sustained from flood damages. In the absence of increased structural protection, flood insurance is an appropriate measure for addressing the catastrophic financial losses present in the Riverview Industrial Park. Flood insurance has a benefit-cost ratio of 0.91.

Channel Improvement (Alternative 5). - Channel improvement was considered as an alternative to reduce flood stages in the project area. This alternative would increase the area of the river channel, mainly through deepening, to allow passage of larger flows without increases in river stage during floods.

Preliminary analysis indicated, however, that channel improvement would have to be continued several miles downstream even to produce a 1-foot stage reduction at the design flood discharge. An improvement of this scale would involve dredging and disposal of over 4 million cubic yards of material. The first cost of such an improvement would be about $23.7 million. The average annual cost would be about $2,000,000 including yearly maintenance. This plan would reduce flood damages by only about $100,400 annually and would have a benefit-cost ratio of 0.05. Also, since flood profiles indicate an average slope of less than 1 foot per mile in the reach under consideration, it is apparent that a raised level of protection through stage reductions attainable for any scale of channel enlargement would not justify the work, either as an alternative by itself or as a measure combined in a plan with another alternative.

Reservoir Development (Alternative 6). - Reservoirs for storage will reduce flood stages when it is possible to build them at a desirable location. Reservoir storage on the Upper Mississippi or Minnesota River could be considered as an alternative for lowering flood stages and increasing the level of protection for the existing St. Paul project. Each river drains about half of the area above the St. Paul project (see plate 6-6).

a. Mississippi River. - Localized flood control is provided by the natural lakes and swamps and six Corps of Engineers reservoirs in the Mississippi River headwaters area. The reservoirs, however, are capable of stage reductions in only a short reach downstream of the dams. Also, because the drainage area controlled by these reservoirs is only one-fourth of the total Mississippi River drainage above the confluence with the Minnesota River, flood control offered to the Twin Cities by these dams is minimal. Low-flow augmentation is the primary purpose for the existence of the headwaters reservoirs.

In addition to 6 Corps headwaters dams, 13 hydroelectric dams are located in the Upper Mississippi River basin above the St. Paul project. These plants are generally operated on a run-of-river basis and offer little flood control benefit. Of the three navigation locks and dams on the Mississippi River above the St. Paul project, two are used for hydropower generation. They have comparatively little available storage and operate within narrow pool fluctuation limits. Thus, they have little positive effect on reducing stages downstream.

The Corps of Engineers recommended construction of a Mississippi River Headwaters area dam and reservoir in the interim report, "Mississippi River above Coon Rapids Dam Near Minneapolis, Minnesota, Days High Landing Dam, Minnesota," dated March 1972. The project was justified in the interests of stabilizing water levels for wild rice production and for wildlife propagation but the project would not offer flood damage reduction for the Twin Cities area.

In general, conditions in the Mississippi River basin above the Twin Cities do not favor further storage development. Practically all the reservoir possibilities are broad, shallow lakes. The large change in area with comparatively small change in stage, the consequent cost of flowage and clearing, and the adverse environmental effects discourage reservoir development, especially since nearly every lake has been developed for resort purposes.

b. Minnesota River. - In 1966 the Corps submitted a "Phase I Feasibility Report for Flood Control and Related Purposes, Minnesota River Basin, Minnesota and South Dakota." The report found that larger-scale reservoir development would be economically feasible and indicated that reservoirs would provide substantial flood control on the Minnesota River and reduce flood stages on the Mississippi River at and downstream from the Twin Cities The Blue Earth reservoir was one of those recommended for further study. The draft interim survey report recommending a large dam on the Blue Earth River was completed in 1970 but never released due to a lack of local and State support and strong social and environmental objections. A 1976 economic update for the Blue Earth reservoir showed a benefit-cost ratio of 0.98.

The Soil Conservation Service, cooperating with the Southern Minnesota Rivers Basin Commission, recently completed a type IV water resources study of the Minnesota River basin and southern Minnesota tributaries to the Mississippi River. The study indicated possible economic feasibility for development of 81 reservoirs in 5 subbasins of the Minnesota River. The Governor of Minnesota requested Congress to authorize the Corps of Engineers and the Soil Conservation Service to work together on an implementation study for the five-subbasin area. A study under Public Law 87-639 is under way. Even with development of all 81 sites, however, stage reduction in the St. Paul area would be minimal because the location of these reservoir sites is so far upstream.

c. Summary. - Reservoir storage development in the Upper Mississippi River basin is not a technically sound or economically realistic way to achieve stage reductions at St. Paul. Large-scale reservoir development in the Minnesota River basin is technically possible but would have marginal economic feasibility at best and was not supported by the State of Minnesota. In addition, experience in other areas of the St. Paul District and the Nation has shown that proposals for large-scale reservoir development encounter objections by landowners, environmental interests, fish and wildlife agencies, and those concerned with preservation of natural and historic values. In many cases, by the time all objections are met, costs have increased to a point where economic feasibility becomes questionable as with the Blue Earth site. At this time it appears that reservoir development is not a viable alternative for lowering flood stages and increasing the level of protection for the existing St. Paul project.

Raising Existing Barriers (Alternative 7). - This alternative would consider raising the existing levees and floodwalls, thus increasing the level of flood protection. Any raise in the level of the top of the barrier necessitates a reanalysis of seepage and interior drainage. A review of these important factors has been completed at a level of detail suitable for a stage 3 report. These factors have been incorporated into the cost estimates and are depicted in the sketches on plates in appendix 3. For this report the following options were considered:

a. 2-foot raise (alternative 7A). - This alternative elevation was selected for analysis because the South St. Paul project, authorized concurrently with the St. Paul project, was built with a relative level of protection 2 feet higher than the St. Paul project. Also, at the time of the 1965 flood the city of St. Paul placed an additional lift of about 2 feet along the levees and attached temporary wooden flashboards to the concrete floodwalls.

This option would be the easiest raise to implement because it is a modest increase and modifications required would be relatively simple. The upper end of the project is topped by a high quality blacktop road.

The most feasible method of raising this portion of the project appears to be the creation of a road flanking levee. The floodwall portions of the barrier could be raised by capping the existing wall with a concrete extension. The ordinary levee sections could be simply raised with additional fill and suitably topsoiled and seeded. Typical barriers would be similar to sections shown on plates 3-1 through 3-8.

b. 4-foot raise (alternative 7B). - This alternative elevation was selected because it is an intermediate option between the 2-foot and standard project flood raise alternatives. A 4-foot raise also appears to be the limiting raise which the concrete floodwall could tolerate without requiring complete abandonment and tearing out of existing floodwall foundations. The levees in open areas could accommodate an increment of this magnitude. Provisions for seepage control and interior drainage modifications would be more costly than those for alternative 7A.

c. Standard project flood raise (alternative 7C). - Standard project flood is used as an expression of the degree of protection that should be sought in flood control design where failures might be disastrous. To protect against a standard project flood would require raising the level of existing flood barriers about 8 feet. A raise of this magnitude would require major and costly modifications to floodwall foundations and facilities for interior drainage and seepage control.

The following table summarizes data and compares the various levels of protection provided with the incremental raises discussed above.

Comparison of existing conditions and flood barrier raises

Alternative	Design flow (cfs)	Exceedence (percent)	Expected occurrence (years)	Design water surface elevation (2) (msl, 1912 adjustment)	Freeboard (feet)(1) Above Corps of Engineers 1-percent flood	Above (4) intermediate regional flood	Above 1965 flood of record	First cost	Average annual cost (3)	Average annual equivalent damages remaining	Average annual benefits	Benefit-cost ratio
Existing conditions	168,000	0.6	167	709.7	4.6	3.6	2.6	-	-	$938,200	-	-
Alternative 7A 2-foot raise	187,000	0.3	333	711.4	6.3	5.3	4.3	$4,960,000	$367,900	480,100	$458,100	1.25
Alternative 7B 4-foot raise	210,000	0.17	588	713.3	8.3	7.2	6.2	7,000,000	520,000	278,300	659,900	1.27
Alternative 7C Standard project flood raise	260,000	0.05	2,000	717.3	12.3	11.2	10.2	17,790,000	1,319,000	88,400	849,800	0.64

(1) Freeboard is 2.8 feet for existing conditions and 3.0 feet for alternative raises above the design water surface elevation.

(2) At U.S. Geological Survey gage. For location, see Plate 1-5.

(3) Based on 7 3/8% interest, 100-year project life. Includes operation, maintenance and major replacements.

(4) For floodplain management purposes, an administratively agreed upon value of 160,000 cfs for the intermediate regional flood is used in the St. Paul area.

Comparative Assessment and Evaluation of Plans

Narrowing the Array of Alternatives. - Generally a final plan is recommended for implementation during stage 3 studies. Investigations are made in the detail required to determine which of several plans yields the most acceptable solution. To determine acceptability, it is necessary to evaluate the contributions each alternative makes to the specific planning objectives and the national water resources objectives. Evaluation entails a trade-off process resulting in ranking of alternatives which provides a basis for recommending further study or selecting an alternative which merits consideration as the most acceptable plan.

Contribution of Alternatives to Specific Objectives. - All of the nonstructural alternatives considered offer an increase in the level of protection or a reduction in possible future flood damages. The removal of existing structures from the flood hazard area (alternative 2) is by far the most effective method for reducing flood damages. However, the plan is not economically feasible and lacks support. Flood proofing also has a high potential for reducing damages but it also is not acceptable to the public in this particular instance although there are other cases where it would certainly be acceptable and beneficial. The other nonstructural measure - flood insurance - is practical. This measure would not increase the level of flood protection, but would mitigate future damages through the reimbursement of property owners for flood damages through insurance. This alternative may be acceptable to some. Most important, the above nonstructural alternatives do not effectively use the flood protection offered by the existing St. Paul project. The Riverview area is currently considered outside the flood hazard area by State law and local ordinances. Local people, therefore, do not see the need for and are not willing to support nonstructural flood control measures inside the area currently protected by the Corps of Engineers flood barrier.

The structural plans offer added flood protection in varying degrees. Channel improvements and reservoir development, however, are limited technically to reducing stages at the St. Paul project. The flood barrier raise appears to be the alternative which best satisfies the specific planning objectives while being supported by the publics. The following table summarizes the economic, environmental, and social effects of the alternative plans.

Summary impact assessment and evaluation of alternatives

Item	Alternative 1 No action	Alternative 2 Removal of existing structures	Alternative 3 Individually protecting structures	Alternative 4 (1) Flood insurance and floodplain regulations	Alternative 5 Channel improvements	Alternative 6 Reservoir development (considers Blue Earth only)	Alternative 7A 2-foot barrier raise	Alternative 7B 4-foot barrier raise	Alternative 7C Standard project flood barrier raise
PLAN DESCRIPTION	Maintain status quo, allowing continued development and growth of the Riverview area. Continued dependence on emergency flood control for flood events above project design levels.	Complete removal of all flood prone buildings and contents from Riverview Industrial Area.	Raise, waterproof or protect by barriers buildings which can be protected in this manner. Remove all other flood prone buildings.	Immediately regulate future growth in Riverview Industrial Area. Make flood insurance mandatory for existing structures.	Make existing Mississippi River channel more efficient by deepening upstream, downstream, and adjacent to the existing project.	Considers construction of Blue Earth Reservoir in Minnesota River basin.	Raise level of protection of existing flood barriers by 2 feet.	Raise level of protection of existing flood barriers by 4 feet.	Raise level of protection of existing flood barriers.
ECONOMIC IMPACTS									
Beneficial	N/A (base condition)	$920,000 average annual equivalent benefits.	About $800,000 average annual equivalent benefits.	About $938,200 average annual equivalent benefits.	About $100,400 average annual equivalent benefits.	$19,300,000 average annual equivalent benefits (about $320,000 average annual benefits to St. Paul).	$458,100 average annual equivalent benefits.	$659,900 average annual equivalent benefits.	$849,800 average annual equivalent benefits.
Adverse	N/A (base condition)	$10,046,000 average annual costs.	$4,798,000 average annual costs.	$1,032,000 average annual costs.	About $2,000,000 average annual costs.	$19,600,000 average annual costs.	$367,900 average annual costs.	$520,000 average annual costs.	$1,319,000 average annual costs.
Net	N/A (base condition)	-$9,126,000	-$3,998,000	-$93,800	-$1,899,600	-$300,000	+$90,[illegible]00	+$139,900	-$469,200
Other effects		About $5 million in yearly tax revenue lost to St. Paul.*	About $3 million in yearly tax revenue lost by St. Paul.*						
ENVIRONMENTAL IMPACTS									
Beneficial	N/A (base condition)	256 acres available for open space and parkland use in St. Paul.	About 150 acres would be made available for open space and parkland use in downtown St. Paul area.	Little change from base condition except that 42 acres of developable land would be left undeveloped, assuming regulations were instituted immediately. 42 acres could be developed if elevated above 100-year flood.	None.	4,300-acre conservation pool would be available for recreation. An additional 4,300-acre game management area is proposed above conservation pool. Minor benefits to waterfowl.	No effect.	No effect.	No effect.
Adverse	N/A (base condition)	An area of equivalent size to evacuated area would be required for resettlement of industries. Dependent upon area selected, net environmental impacts may may be greater, less than, or no net change. Noise increased during evacuation.* Aesthetic values improved.*	Same as alternative 2.	No change from base condition.	Excavation of 4 million cubic yards from Mississippi River channel would require on-land placement. About 100 acres of land adjacent to the channel would be adversely affected by dredged material placement. Aesthetically detracting dredged material piles would be created.* Water quality would be adversely affected during dredging.*	About 28,200 acres of land in reservoir area would be acquired in fee or flowage easement. All categories of wildlife, except for waterfowl, would be adversely affected. Aesthetics improved in reservoir lake area.* Community of Garden City made less cohesive.*	Minor temporary adverse effects on grassed wildlife habitat near landward toe and on levees. Approximately 10 acres affected. Slight noise increase during construction.*	Same as 7A but with about 16 acres affected.	Potential adverse effect on National Register site.
CONTRIBUTION TO SPECIFIC PLANNING OBJECTIVE									
Level of protection	166-year flood	Nearly all floods	Nearly all floods.	166-year flood, same as base condition. Flood insurance could cover damages from all floods.	250-year flood.	300-year flood.	333-year flood.	588-year flood.	Standard project flood (corresponding to 2,000-year event).
Reduction in damages	$938,200 (base condition).	Damages reduced by 98 percent.	Damages reduced by 85 percent.	Floodplain regulations would not reduce flood damages as regulations are not required. Flood insurance would not reduce damages but only reimburse them.	Damages reduced by 11 percent.	Damages reduced by 34 percent.	Damages reduced by 49 percent.	Damages reduced by 70 percent.	Damages reduced by 91 percent.

Summary impact assessment and evaluation of alternatives (1)(2)

Item	Alternative 1 No action	Alternative 2 Removal of existing structures	Alternative 3 Individually protecting structures	Alternative 4 Flood insurance and floodplain regulations	Alternative 5 Channel improvements	Alternative 6 Reservoir development (considers Blue Earth only)	Alternative 7a [illegible] barrier raise	Alternative 7b [illegible] barrier raise	Alternative 7c Standard project flood barrier raise
NATIONAL ACCOUNTS									
National economic development	N/A (base condition)	Decrease by $9,126,000 annually.	Decrease by $3,498,000 annually.	Decrease by $1,[illegible]2,000 annually.	Decrease by $1,899,000 annually.	Decrease by $300,000 annually.	[illegible]	[illegible]	Decrease [illegible] annually.
Environmental quality	N/A (base condition)	Increase, assuming relocation of businesses in nonsensitive area.	Slightly increase, assuming relocation of businesses in nonsensitive area.	Minor positive change.	Decrease.	Decrease.	Minor temporary decrease.	Minor temporary decrease.	Minor temporary decrease.
Social well-being	N/A (base condition)	Increased health and safety. Relocate 131 businesses.*	Increased health and safety. Relocate about 30 businesses.*	Increased health and safety.	Increased health and safety.	Increased health and safety. Small municipality of Carver City relocated.*	Increased health and safety.	Increased health and safety.	Increased health and safety.
Regional development	N/A (base condition)	Provide 260 jobs during construction.* Over 5,500 jobs could permanently be lost in region.*	Provide 160 jobs during construction. Up to about 800 jobs could permanently be lost in region.*	Provide 2 jobs.*	Provide 50 jobs.*	Provide 400 jobs.*	Provide 2[illegible] jobs.*	Provide [illegible] jobs.*	Provide 6[illegible] jobs.*
RESPONSE TO EVALUATION CRITERIA									
Acceptability	N/A (base condition)	Not acceptable.	Not acceptable.	Acceptable to some	Likely unacceptable to State of Minnesota and fish and wildlife interests.	Unacceptable to State of Minnesota.	Acceptable.	Acceptable.	Acceptable.
Completeness	N/A (base condition)	Complete.	Complete.	Complete; however future program maintenance and payments would be required. Also dependent on insurance participation.	Would require substantial future expenditures for maintenance.	Complete.	Complete.	Complete.	Complete.
Effectiveness	N/A (base condition)	Highly effective.	Effective.	Generally ineffective in reducing flood damages	Effective technically to reduce stages a small amount.	Reasonably effective.	Effective.	Effective.	Highly effective technically but economically lacking in net benefits.
Efficiency	N/A (base condition)	Very inefficient.	Inefficient.	Moderately efficient	Inefficient.	Inefficient to reduce stages at St. Paul.	Efficient	Efficient	Efficient
Certainty	N/A (base condition)	Very certain for flood control. Environmental effects uncertain.	Certain.	Fairly certain.	Moderately uncertain.	Certain.	Certain.	Certain.	Certain.
Geographic scope	N/A (base condition)	Basically affect only project area.	Basically affects only project area.	Affects only project area.	Decreases flood stages upstream and downstream of project.	Decreases flood stages on lower Minnesota River to La Crosse, Wisconsin, on Mississippi River.	Slight stage increases in downstream flooding.	Slight stage increases in downstream flooding.	Slight stage increases in downstream flooding.
Benefit-cost ratio	N/A (base condition)	0.09	0.17	N/A	0.05	0.98	[illegible]	[illegible]	[illegible]
Reversibility	N/A (base condition)	Reversible at very high cost.	Reversible at very high cost.	Reversible.	In long term	In long term.			
Stability	N/A (base condition)	Medium.	Medium.	Medium.	Low.	Medium.	Medium.	Medium.	Medium.
Implementation responsibility	N/A (base condition)	Corps of Engineers City of St. Paul Individual industries.	Corps of Engineers, City of St. Paul, Individual Industries.	City of St. Paul, Individual Industries	Corps of Engineers.	Corps of Engineers.	Corps of Engineers.	Corps of Engineers	Corps of Engineers.

(1) Flood insurance payments not considered NED benefits.
(2) Significant impacts specified in Section 122, Public Law 91-611, are shown with asterisk (*).

Comparison of Identified Alternatives. - At this point in the feasibility study, we have identified a wide range of alternative measures and analyzed these alternatives in regard to satisfaction of the specific objectives; i.e., the reasons for the study. A final selected plan of development, however, must not only address the specific objectives but also optimize contributions to the twin national objectives of national economic development and environmental quality. To evaluate these contributions, all alternatives were again analyzed, first in regard to national economic development and then for environmental quality. Alternatives showing the most positive net contribution to each national objective were identified.

National economic development benefits are determined by analyzing and measuring the net value of goods and services derived from each alternative. Positive contributions to national economic development are the flood control benefits credited to each alternative while negative contributions are the costs to the Nation for development of each alternative. Net contributions are the difference between positive and negative contributions and are the standard by which alternatives are compared.

As shown in the table on page 42, of the alternatives evaluated, alternative 7B, a 4-foot barrier raise, has the highest net benefits. Alternative 7A, a 2-foot barrier raise, has nearly identical but slightly lower net benefits. No other alternatives have net benefits approaching these two. Therefore, at this point a 4-foot barrier raise appears to best satisfy the national economic development objective and is considered the best NED framework alternative.

Net environmental quality contributions are the basis for selection of an alternative which best satisfies the EQ objective. Examination of the table on page 42 reveals that only alternative 2, removal of existing structures from the flood hazard area, or alternative 3, individually protecting structures with some removals, could result in significant net positive environmental quality benefits. However, these benefits would occur only if industries and businesses relocated into an environmentally

nonsensitive area as compared with the environmentally rehabilitated evacuated area. Little control could be exercised in the selection of the area for relocation. Therefore, little certainty as to the true amount of net benefits can be projected. Net environmental benefits from these alternatives could conceivably be negative.

Floodplain regulations and flood insurance, alternative 4, could result in positive environmental quality benefits if regulations were imposed before base year conditions, as shown in the table on page 42. However, if regulations and zoning were imposed after the base year, no environmental quality benefits could be realized as the entire area would already be fully developed. No land would be left for environmental quality enhancement as compared to the base condition. All other plans investigated decrease environmental quality attributes.

Based on the above discussion it is difficult to label a plan as that which best satisfies the environmental quality objective. Since no alternative would offer net positive benefits with any certainty, the alternative which is least damaging to the biological environment while offering social benefit can be considered as that best satisfying this objective. Using this reasoning, the 2-foot raise is suggested as the alternative best satisfying the criteria of an environmental quality framework.

Conclusions

All of the alternatives analyzed provide some degree of satisfaction to specific objectives. However, several of the alternatives do not satisfy other considerations of the study or fail to meet evaluation criteria. Alternative 2 (remove structures) and alternative 3 (individually protecting structures) are unacceptable to the businesses occupying the structures. Alternative 4 (floodplain regulation and flood insurance) is unacceptable to the project's local sponsor, the city of St. Paul, since the city is actively developing the area through the St. Paul Port Authority. Alternative 5 (channel improvement) and alternative 6 (reservoir development) appear to be

unacceptable to the State of Minnesota, are of questionable effectiveness, and do not satisfy the benefit-cost ratio. Alternative 7C (standard project flood barrier raise) has an unacceptably low benefit-cost ratio that does not satisfy the national economic development objective. Only alternatives 7A and 7B (raising the flood barriers) have positive net benefits, thus satisfying the national economic development objective. Environmental quality impacts are severely negative for alternatives 5 and 6.

ASSESSMENT AND EVALUATION OF DETAILED PLANS

The objective of the assessment and evaluation of detailed plans is to analyze the alternative measures available to the area under study which have passed the screening provided under the previous section on Formulation of Preliminary Plans. This process provides a means to assess their feasibility and acceptability in order to arrive at a recommended plan of improvement. The evaluation must be compatible with other area plans and comply with all Federal, State, and local laws and regulations.

PLAN A (ALTERNATIVE 1) NO ACTION

Plan Description

As its name implies, the no action alternative consists of continuing the present protective works with no important modifications. This alternative constitutes the base condition from which performance of other alternatives can be measured.

Impact Assessment

The adoption of this alternative would provide many positive impacts. Since the existing project has protected the area from the maximum flood of record, the expenditure of funds for additional protection needs to be carefully justified. The no action choice would avoid substantial expenditure of funds by city, State, and Federal units of government, thereby avoiding appreciable tax burdens on the taxpayers. However, there would

still be the computed average annual damages estimated at $604,800 for current conditions and $825,100 for the base year when the area is expected to be fully developed. This impact would continue to be met by dependence on emergency flood control for those isolated flood events exceeding project design levels. As was done in the 1965 flood, the city would provide increased elevation on the levees and flashboards on the existing floodwalls.

Evaluation and Trade-Off Analysis

This evaluation of the status quo plan indicates that no trade-off analysis would be required.

Mitigation Requirements

Since no changes would be made in resources, it follows that mitigation measures would not be applicable.

Implementation Responsibilities

Since there would be no cash costs, there would also be no separable implementation responsibilities by any governmental units or commercial interests.

Public Views

As would be expected, the no action alternative received only limited support from those who replied to our request for input during the previous iterations. Substantive comments were provided by the Metropolitan Airports Commission and the Aeronautics Division of the Minnesota Department of Transportation. These agencies are concerned about the effects of any levee raise on the St. Paul Downtown Airport glide angle and they prefer the status quo alternative. The Minnesota Department of Natural Resources questioned the need for a raise in the level of protection, especially since the area is already protected to a level above the 1-percent chance flood.

PLAN B (ALTERNATIVE 7A) 2-FOOT BARRIER RAISE

Plan Description

This alternative consists of raising the top elevation of the existing levees and floodwalls 2 feet. As a planned companion move connected with the original construction, the upper end of the levee was topped by a blacktop road, concrete curbs, and grassed boulevards which have already raised the effective height of the levee by close to 1 foot. The lower end was raised over 1 foot as an emergency flood fight precaution in 1965, and some of this material has remained in place. This option was originally chosen to be studied because the South St. Paul project, authorized concurrently with the St. Paul project but built after the 1965 maximum flood of record, was constructed with a relative level of protection 2 feet higher than the St. Paul project.

Because of existing commercial and industrial development and the way it is related to the present flood control works, raising the level of protection in accordance with present Corps of Engineers standards calls for changing solutions over the different reaches of the present project. These are presented starting with station 0+00 at the upper end and ending at station 152+00 at the lower end (15,200 feet) near the Lafayette Freeway.

Station 0+00 to 10+00 (Levee). - Raise the barrier on the south side of the existing levee and include a 20-foot drainage berm on the landward side.

Station 10+00 to 33+00 and Station 39+00 to 41+00 (Levee). - Raise the levee on the river side plus a 20-foot drainage berm on the landward side.

Station 41+00 to 66+00 (Floodwall). - Raise the floodwall and add a landward berm for lateral support. Install a new collector pipe.

Station 66+00 to 80+00 (Levee and Floodwall). - Raise the levee and add a 45-foot drainage berm with collector pipe. Raise the floodwall adjacent to the foundry (station 67+74 to 69+32).

Station 80+00 to 86+00 (Floodwall). - Raise the floodwall adjacent to the fertilizer plant.

Station 86+00 to 98+00 (Levee). - Raise the levee and raise the railroad track to accommodate a 45-foot drainage berm with collector pipe.

Station 98+00 to 111+00 (Levee). - Raise the levee and add a 45-foot drainage berm with collector pipe.

Station 111+00 to 123+00 (Levee includes a railroad closure, a street ramp, and an airport runway approach). - Raise the levee and add a 45-foot drainage berm with collector pipe.

Station 123+00 to 152+00 (Levee). - Raise the levee and install a seepage barrier on the riverward side of the levee since available land will not allow installation of a drainage berm.

In addition to the above items, it is necessary to modify 8 sandbag closures, raise 4,300 feet of railroad track, raise 1 road ramp, modify 8 gate wells, raise 25 manholes and catch basins, drive about 71,000 feet of sheet pile, modify 8 closure structures, modify 3 pump stations, and shorten and rebuild the closure structure at the lower end of the project. A flood emergency preparedness plan would be a necessary adjunct to structural features.

Impact Assessment

For flood warning reports that indicate possible rare flood events in excess of existing project design levels, it is necessary to activate emergency flood control measures at considerable expense and inconvenience to the local governmental units. This action diverts manpower and materials from other public functions where they would have other beneficial uses. An increase in the level of protection such as that provided by the 2-foot barrier raise would therefore enhance social well-being through its beneficial impacts on the quality of life, increased safety, and positive health factors. Construction of the 2-foot raise would cause a short-term increase in noise during the construction period, but no long-term change.

The borrow material for the original project construction was excavated so that the resulting borrow pit provided an area suitable for use as a boat harbor. It is possible to obtain material for this 2-foot raise by increasing the size of this harbor. Accordingly, the increase in the elevation of the top of the levee would encourage added recreational development by assisting the city with its plans for enlarging the harbor and thus would have a beneficial impact on recreation opportunities. The Minnesota State Historic Preservation Office has stated that no cultural resources would be affected by marina enlargement. If borrow material is taken elsewhere, coordination with the appropriate agencies will be required.

From the standpoint of environmental quality, the 2-foot levee raise would require removal of the present grass cover from the areas to be modified which would have a short-term adverse impact on the terrestrial habitat near the landward tow and on the present levees. This work would have a temporary effect on approximately 10 acres of grass that would be reestablished as an integral part of the construction process.

It is proposed to include beautification of the floodwall as part of the design process, thus enhancing the appearance of the wall.

The impacts on community cohesion, desirable growth, tax revenues, property values, and public facility needs would remain essentially the same as with the status quo.

Evaluation and Trade-Off Analysis

An evaluation of the proposal to raise the existing levees 2 feet indicates that, of the action plans, this would be the least damaging as related to existing development. The 2-foot raise would be the easiest to implement. The existing levees would readily allow a raise of this magnitude without substantial increases in right-of-way so the effect on adjacent businesses would be minimized. Investigations so far indicate that the existing floodwall could be extended 2 feet without major foundation problems so the businesses located very close to the wall would experience the least possible interruptions during construction of this raise. Finally, the changes in pumping stations and drainage facilities would be of modest proportions to comply with the latest Corps of Engineers criteria.

Although none of the "raise" plans have any significant environmental problems, this raise would disturb the least amount of grassed area and, consequently, would be the least damaging environmentally.

Mitigation Requirements

Mitigation requirements have been addressed by an interdisciplinary team composed of a landscape architect, an archeologist, and a biologist. The team has determined that, because of the limited environmental impact, no mitigation issues are present.

Implementation Responsibilities

All of the project improvements needed to implement a 2-foot raise would be designed using Corps of Engineers criteria and then constructed under a Corps supervised contract. The city of St. Paul, the local sponsor, would be required to provide all lands, easements, and rights-of-way necessary for the placement of the improvements.

The total first costs under present laws would be Federal expenses estimated to be $4,345,000. The costs for the local share of relocation and lands, easements, and rights-of-way are estimated to be $274,000. However, under the Administration's cost sharing proposal for water resources, the first costs would be allocated 75-percent Federal, 20-percent local, and 5-percent State. Under this proposal the respective costs would be Federal $3,464,000, city of St. Paul $924,000, and State $231,000.

Public Views

Views of Federal Agencies. - All Federal agencies that might possibly have an interest in the study were sent copies of the plan of study, stage 2 report, and draft feasibility report. Replies received indicated no major objections to the study as constituted. The Fish and Wildlife Service, Department of the Interior, stated: "Due to the heavily developed nature of the area proposed for reevaluation, we anticipate no significant impacts to fish and wildlife resources that might result from activities presently considered in the Plan of Study." This letter constitutes the Fish and Wildlife Service coordination report.

Views of Non-Federal Agencies and Others. - The list of agencies that were included as study participants or were sent documents for coordination has previously been displayed in the Introduction. The replies received have been included in appendix 2. The Minnesota Historical Society replied that it is unlikely there are any properties of historical significance that would be affected by the flood control project. The Port Authority of the city of St. Paul agrees that reevaluation and study are necessary and should be pursued. The Housing and Redevelopment Authority indicates that reevaluation is a worthwhile project that ought to be undertaken. The Minnesota Department of Transportation is concerned with possible impacts on the St. Paul Downtown Airport. Because of this concern, it was agreed that any changes would be coordinated with the Metropolitan Airports Commission so that the area within the glide angle set by the Minnesota Department of Aviation would not be raised in a manner that might cause an aviation hazard. Further communication indicates that this area can be provided with freeboard through use of a sandbag closure. The city of St. Paul generally supports a barrier raise, assuming that relocations, city costs, and possible effects on Harriet Island and the community are minimized. The Minnesota Department of Agriculture is understandably concerned with the adequacy of the existing project since its headquarters offices and laboratories are housed within the Riverview Industrial Area of the existing project. The Minnesota Department of Natural Resources expressed concern about the need for a raise but agreed that a raise would be needed to comply with current State floodplain regulations. The other replies are supportive or indicate no involvement with issues of concern to the respective agencies.

PLAN C (ALTERNATIVE 7B) 4-FOOT BARRIER RAISE

Plan Description

This plan consists of raising the top elevation of the existing levees and floodwalls 4 feet and making any other modifications that would be essential to this level of protection. This alternative levee raise was originally selected as an intermediate option between the 2-foot raise and the option for a raise to the standard project flood level. As previously discussed under Plan Description for 2-Foot Barrier Raise, the actual raise at the upper and lower ends would be in the 3-foot range.

Because of existing commercial and industrial development and the way it is related to the present flood control works, raising the level of protection in accordance with present Corps of Engineers standards calls for changing solutions over the different reaches of the present project. These are presented starting with station 0+00 at the upper end and ending at station 152+00 at the lower end (15,200 feet) near the Lafayette Freeway.

Station 0+00 to 12+45 (Road Raise and Levee). - Raise the roadway adjacent to the Yacht Club Marina and include a 35-foot drainage berm on the landward side.

Station 12+45 to 33+00 (Levee). - Raise the levee on the river side plus a 32-foot berm on the land side where possible. Construct a relief well system from stations 16+00 to 33+00 to intercept seepage.

Station 39+00 to 41+00 (Levee). - Raise the levee on the river side. Raise the blacktop road crossing the levee toward Navy Island and replace it.

Station 41+00 to 66+00 (Floodwall). - Drive an additional row of piling adjacent to the existing floodwall. Construct a new raised concrete floodwall against the existing floodwall and tie the new floodwall to the old one with anchors drilled and secured into the existing concrete wall. New floodwall would be landward of the old wall except from station 53+80 to closure structure 3 where new floodwall would be constructed riverward. Remove and reinstall the toe drain conduit. At railroad closure No. 2, rebuild the structural concrete closure.

Station 66+00 to 80+00 (Levee and Floodwall). - Raise levee and add relief wells to intercept seepage (station 66+00 to 67+74). Raise the floodwall adjacent to the foundry (station 67+74 to 69+32). Raise levee and add 58-foot drainage berm (station 69+32 to 77+00). Raise levee and add relief wells (station 77+00 to 80+00).

Station 80+00 to 86+00 (Floodwall). - Raise the floodwall adjacent to the fertilizer plant. Construct a new raised concrete floodwall on the land side against the existing floodwall and tie the new floodwall to the old one with anchors drilled and secured into the existing concrete wall.

Station 86+00 to 98+00 (Levee). - Raise the levee and raise the railroad track to accommodate a 58-foot drainage berm.

Station 98+00 to 111+00 (Levee). - Raise the levee and add a 58-foot drainage berm.

Station 111+00 to 123+00 (Levee includes a railroad closure, a street ramp, and an airport runway approach). - Raise the levee and add a 58-foot drainage berm. Add sandbag closures at new rail and street crossing (station 105+00 and 106+00). Add 32 feet of sheet pile and connect to the existing cutoff wall at the railroad closure. Construct a road raise at the airport access road. Within the area of the airport approach glide angle, limit the raise to avoid hazards to airport users and provide a sandbag closure in this area (station 116+00 to 121+00).

Station 123+00 to 152+00 (Levee). - The railroad track on the east or river side must be moved toward the airport to provide adequate right-of-way for this project increase. Raise the levee using this added land. Since the land on the inner or landward side of the existing project includes development right up to the toe of the levee, the best solution to provide necessary seepage control for this raise is an impervious clay blanket on the riverward side of the levee (station 123+00 to 142+00). Raise levee and add 75-foot drainage berm (station 142+00 to 152+00).

At the railroad closure adjacent to the bluff at the lower end, it is recommended that the existing closure be shortened by extending the levee and providing the required seepage berm. It is necessary to construct a new closure structure at the end of this extension and raise the existing closure structure located at the bluff. A complete itemization of all modifications required is shown in appendix 3, Design and Cost Estimates. A flood emergency preparedness plan would be a necessary adjunct to the structural features.

Impact Assessment

For flood warning reports that indicate possible rare flood events in excess of existing project design levels, it is necessary to activate emergency flood control measures at considerable expense and inconvenience to the local governmental units. This diverts manpower and materials from other public functions where they would have other beneficial uses. An increase in the level of protection such as that provided by the 4-foot barrier raise would therefore enhance social well-being through its beneficial impacts on the quality of life, increased safety, and positive health factors.

Construction of this 4-foot raise would cause a short-term increase in noise during the construction period somewhat greater than that for a 2-foot raise, but no long-term increase. The barrier raise may actually attenuate noise in the long term similar to the effect of a highway noise barrier.

The borrow material for the original project construction was excavated so that the resulting borrow pit provided an area suitable for use as a boat harbor. It is possible to continue to obtain borrow in a way that would increase the harbor area. Accordingly, this increase in the elevation of the top of the levee would encourage added recreation development by assisting the city with its plans for enlarging the harbor and, thus, would have a beneficial impact on recreation opportunities. The Minnesota State Historic Preservation Office has stated that no cultural resources would be affected by marina enlargement. If borrow material is obtained elsewhere, coordination with the appropriate agencies will be required.

From the environmental quality standpoint, the 4-foot raise would require the removal of a somewhat greater amount of grass cover than the 2-foot raise. Thus, this action would have a temporary effect on approximately 16 acres of grass, or 6 acres more than with the 2-foot raise. However, this grass would be replanted after construction. It is proposed to include beautification of the floodwall as part of the design process, thus enhancing the appearance of the wall.

The impact on community cohesion, desirable growth, tax revenues, property values, and public facility needs would remain essentially the same as with the status quo.

Evaluation and Trade-Off Analysis

An evaluation of the proposal to raise the existing levees 4 feet indicates that, of the action plans, this plan would be more damaging than the 2-foot raise but far less damaging than the standard project flood raise of approximately 8 feet. This raise is about the limit of protection that can be implemented without major reconstruction of much of the existing flood control works. This raise would require the acquisition of title to at least 4.6 acres plus temporary easement on several more acres and would cause some interruption during construction to the businesses adjacent to the levee right-of-way.

Although none of the raise plans has significant environmental problems, this 4-foot raise is the median plan as related to grassed area disturbed during construction activities.

Mitigation Requirements

Mitigation requirements have been addressed by an interdisciplinary team composed of a landscape architect, an archeologist, and a biologist. The team has determined that, because of the limited environmental impact, no mitigation issues are present.

Implementation Responsibilities

All of the project improvements needed to implement a 4-foot raise would be designed using Corps of Engineers criteria and then constructed under a Corps supervised contract. The city of St. Paul, the local sponsor, would be required to provide all lands, easements, and rights-of-way necessary for the placement of the improvements.

Under present law, the Federal share of the construction first costs (totaling $6,519,000) is estimated to be $5,954,000. The local costs for lands, easements, and rights-of-way and the local share for relocations are estimated to be $565,000. However, under the Administration's cost sharing proposal for water resources, the cost would be allocated 75-percent Federal, 20-percent local, and 5-percent State. Under this proposal, the respective costs would be Federal $4,889,000, city of St. Paul $1,304,000, and State $326,000.

Public Views

The views of Federal, State, and local agencies and other interests are the same as those presented for plan B.

PLAN D (ALTERNATIVE 7C) STANDARD PROJECT FLOOD BARRIER RAISE

Plan Description

This plan consists of raising the top elevation of the existing levees and floodwalls approximately 8 feet to standard project flood level. The standard project flood represents the flood runoff that can be expected from the most critical combination of precipitation and snowmelt, minimum infiltration losses, and concentration of runoff at a specific location that is considered reasonably characteristic of the region and drainage area involved, excluding extraordinarily rare combinations.

A raise of this magnitude requires major changes in all components of the existing flood protection works. Because of existing commercial and industrial development and the way it is related to the present project, is also would have a significant impact on the adjacent businesses. Raising to this level of protection in accordance with present Corps of Engineers standards calls for changing solutions over the different reaches of the present project. These are presented starting with station 0+00 at the upper end and ending at station 152+00 at the lower end (15,200 feet) near the Lafayette Freeway (see plate 1).

Station 0+00 to 10+00 (Levee). - Raise the barrier on the south side of the existing levee and include a 58-foot drainage berm on the landward side. To provide adequate right-of-way, relocate Metro Recycling to a new site. The city's plans for development of the river corridor tentatively include acquisition of the railroad right-of-way which would allow permanent closing of railroad closure No. 1. If this corridor plan is not implemented, the closure must be rebuilt with a 44-foot piling and an 8-foot raise to the top of the concrete closure walls. The road ramp in this reach must also be raised at least 5 feet with a sandbag closure to provide freeboard.

Station 10+00 to 33+00 (Levee). - Abandon the road on the top of the levee and raise the levee approximately 8 feet. Construct a 58-foot drainage berm on the land side. Provide protection for and access to the Moses Street pumping station. To provide adequate right-of-way for the new drainage berm, relocate McPhillips Sweeping/Snow Removal operation, Kaplan Battery Reclamation, and McPhillips Roofing Company.

Station 39+00 to 41+00 (Levee). - Raise the levee on the river side plus a 58-foot berm on the land side. Eliminate the road through the levee at this point and extend the continuous levee to the Wabasha Street embankment.

Station 41+00 to 66+00 (Floodwall). - This level of raise would require removal of the existing concrete floodwall to extend the in-place piling to the increased depths required by this level of protection. Remove and reinstall the toe drain conduit. At railroad closure No. 2, rebuild the structural concrete closure. At the Custer Street pumping station, provide a floodwall and relocate the electrical substation.

Station 66+00 to 80+00 (Levee and Floodwall). - Raise the levee and add an 83-foot drainage berm with collector pipe. Raise the floodwall adjacent to the foundry (station 67+74 to 69+32).

Station 80+00 to 86+00 (Floodwall). - Raise the floodwall adjacent to the fertilizer plant. Remove a portion of the fertilizer building to allow for additional sheet piling to be driven. Construct a new raised concrete floodwall on the land side against the existing floodwall, tie the new floodwall to the old one with anchors drilled and secured into the existing concrete wall and add a landward berm for lateral support.

Station 86+00 to 98+00 (Levee). - Relocate the railroad track away from the levee to provide adequate right-of-way for the enlarged levee. On the landward side, provide an 83-foot drainage berm with collector pipe.

Station 98+00 to 111+00 (Levee). - Raise the levee and add an 83-foot drainage berm with collector pipe.

Station 111+00 to 123+00 (levee includes a railroad closure, a street ramp, and an airport runway approach). - Raise the levee and add an 83-foot drainage berm with collector pipe. Add 44 feet of sheet pile and connect it to the existing cutoff wall at the railroad closure. Within the area of the airport approach glide angle, limit the raise to avoid hazards to airport users and provide a sandbag closure in this area. Construct a road raise at the airport access road.

Station 123+00 to 152+00 (Levee). - The railroad track on the east or river side must be moved toward the airport to provide adequate right-of-way for this project increase. Raise the levee using this added land. Since the land on the inner or landward side of the existing project includes development right up to the toe of the levee, the best solution to provide necessary seepage control for this raise would be an interconnected system of relief wells.

At the railroad closure adjacent to the bluff at the lower end, it is recommended that the existing closure be shortened by extending the levee and providing the required seepage berm. It is necessary to construct a new closure structure at the end of this extension and raise the existing closure structure at the bluff.

In addition to the items previously covered, it is necessary to modify 8 sandbag closures, raise 4,300 feet of railroad track, raise 2 road ramps, modify 8 gate wells, raise 25 manholes and catch basins, drive about 72,000 feet of sheet pile, modify 8 closure structures, and modify 3 pump stations. A flood emergency preparedness plan would be a necessary adjunct to structural measures.

Impact Assessment

For flood warning reports that indicate possible rare flood events in excess of existing project design levels, it is necessary to activate emergency flood control measures at considerable expense and inconvenience to the local governmental units. This action diverts manpower and materials from other public functions where they would have other beneficial uses.

A substantial increase in the level of protection such as that provided by this standard project flood raise of about 8 feet would therefore enhance social well-being through its beneficial impacts on the quality of life, increased safety, and positive health factors.

Construction of this raise would incur a short-term increase in noise during the construction period appreciably greater than that for either the 2- or 4-foot raise, but no long-term increase. A barrier of this magnitude would undoubtedly attenuate noise in the long term similar to the effect of a highway noise barrier.

The borrow material for the original project construction was excavated so that the resulting borrow pit provided an area suitable for use as a boat harbor. It is possible to continue to obtain the large quantity of material for this raise from the same source, thus increasing the harbor area. Accordingly, this increase in the elevation of the top of the levee would encourage added recreation development by assisting the city with its plans for enlarging the harbor and thus would have a beneficial impact on recreation opportunities. The Minnesota State Historic Preservation Office has stated that no cultural resources would be affected by marina enlargement. If borrow material is obtained elsewhere, coordination with the appropriate agencies will be required.

From the environmental quality standpoint, the 8-foot raise would require the greatest removal of grass cover of any of the three raise options. This raise would have a temporary effect on approximately 30 acres of grassed area, twice as much as the 4-foot raise and three times as much as the 2-foot raise. However, this grass cover would be reestablished under the usual construction contract.

Abandonment of the roadway would necessitate development of other parking for the marina facilities.

Beautification of the floodwall would be included as part of the design process, thus enhancing the appearance of the wall.

The impact on community cohesion, desirable growth, tax revenues, property values, and public facility needs would remain essentially the same as with the status quo.

The computed water surface elevation at the Minnesota Boat Club boathouse during a standard project flood would be 1.1 feet higher than the without condition. Subsequently, the second floor of the boathouse may be adversely affected.

Evaluation and Trade-Off Analysis

An evaluation of the proposal to raise the existing levees to standard project flood level, an increase of approximately 8 feet, indicates that this raise would be the most disruptive and most damaging of the three options to raise the level of protection. This raise would require the removal and replacement of most of the reinforced-concrete floodwalls, major changes in interior drainage and seepage control, and acquisition of title to at least 8 additional acres plus temporary easement on several more acres. Accordingly, the businesses located adjacent to the barrier right-of-way would experience significant temporary and some permanent disruption because of construction of a raise of this magnitude.

Although none of the "raise" plans have significant environmental problems, this standard project flood raise would cause the greatest environmental disruption of the three plans.

Mitigation Requirements

Mitigation requirements have been addressed by an interdisciplinary team composed of a landscape architect, an archeologist, and a biologist. The team has determined that an 8-foot barrier raise could have adverse impacts on the Minnesota Boat Club boathouse. If this alternative were adopted, coordination with the Adisory Council on Historic Places and the Minnesota Historic Preservation Office would be required.

Implementation Responsibilities

All of the project improvements needed to implement the standard project flood raise would be designed using Corps of Engineers criteria and then constructed under a Corps supervised contract. The city of St. Paul, the local sponsor, would be required to provide all lands, easements, and rights-of-way necessary for the siting of the improvements.

Under present law, the Federal share of the construction first costs (totaling $16,568,000) is estimated to be $14,415,000. The local costs for the local share of relocations and lands, easements, and rights-of-way are estimated to be $2,153,000. However, under the Administration's cost sharing proposal for water resources, the costs would be allocated 75-percent Federal, 20-percent local, and 5-percent State. Under this proposal the respective costs would be Federal $12,426,000, city of St. Paul $3,314,000, and State $828,000.

Public Views

The views of Federal, State, and local agencies and other interests are the same as those presented for plan B.

COMPARISON OF DETAILED PLANS

Three steps were taken to assess and evaluate the acceptable and feasible remaining alternative plans.

1. Appraise fulfillment of local planning objectives:

   a. Determine present and projected future needs within the original project area.

   b. Evaluate compatibility with local plans of options that can be applied to meet these needs.

   c. Avoid conflict with present land use and expected future uses.

   d. Minimize local cooperation requirements.

2. Appraise fulfillment of national objectives:

   a. National economic development (NED).
   b. Environmental quality (EQ).
   c. Regional development (RD).
   d. Social well-being (SWB).

3. Apply a set of evaluation criteria:

a. The acceptability of a plan is determined by analyzing its acceptance by the public. A plan is acceptable if it is, or is likely to be, supported by some significant segment of the public.

b. The completeness of a plan is determined by analyzing whether all necessary investments or other actions necessary to insure full attainment of the plan have been included.

c. The effectiveness of a plan is determined by analyzing the plan's technical performance.

d. The efficiency of a plan is determined by analyzing the plan's ability to achieve the planning objectives and NED and EQ outputs in the least costly way.

e. The certainty of a plan is determined by analyzing in general terms the likelihood that implementation of the plan would achieve the planning objectives and contribute to the NED and EQ accounts.

f. The geographic scope is determined by analyzing the relevancy of the geographic area encompassed by the plan; it must be large enough to encompass a full understanding of the problems and focused enough to make the proposed solutions effective.

g. The NED benefit-cost ratio of a plan is determined by analyzing the economic benefits in relationship to the economic costs.

h. The reversibility of a plan is determined by analyzing the capability, as public needs and values change or should unusual future circumstances so warrant, of restoring the partially or fully implemented plan to approximate the "without condition".

i. The stability of a plan is determined by analyzing the range of alternative futures, data, and/or assumptions which can be meaningfully accommodated within the recommended plan or minor modifications. Greater stability generally indicates a more desirable plan.

The System of Accounts is a display requirement of the Water Resources Council Principles and Standards and is an integral part of the planning process. The System of Accounts displays all significant beneficial and adverse contributions of each alternative carried through the final planning stage and provides a useful tool to assist in the selection process. It also satisfies the display requirements of Section 122, Public Law 91-611, River and Harbor and Flood Control Act of 1970. The following tables display the breadth and detail of the assessment and evaluation of all alternative plans.

Item	No action plan: Maintain status quo, allowing continued development and growth of the Riverview area	System of accounts: 2-foot barrier raise: Raise level of protection of existing flood barrier by 2 feet	4-foot barrier raise: Raise level of protection of existing flood barrier by 4 feet	Standard project flood barrier raise: Raise level of protection of existing flood barrier by 8 feet
1. National economic development (NED)				
A. Beneficial impacts				
(1) Damages prevented	Base condition, no benefits.	Average annual equivalent benefits of $458,100 3, 4, 7, 9	Average annual equivalent benefits of $659,900 3, 4, 7, 9	Average annual equivalent benefits of $849,900 3, 4, 7, 9
(2) Construction employment	Base condition, no benefits.	Average annual benefits of $46,800 1, 6, 7, 9	Average annual benefits of $63,200 1, 6, 7, 9	Average annual benefits of $135,000 1, 6, 7, 9
Total beneficial impacts	None			
B. Adverse impacts	Base condition, average annual costs of $938,200.	Average annual cost of $367,900 3, 4, 7, 9	Average annual cost of $520,000 3, 5, 7, 9	Average annual cost of $1,319,000 3, 5, 7, 9
C. Net NED benefits				
2. Environmental quality				
A. Environmental quality enhanced	Base condition, no change.	Beautification of floodwall would improve aesthetics 1, 6, 8, 9	Beautification of floodwall would improve aesthetics 1, 6, 8, 9	Beautification of floodwall would improve aesthetics 1, 6, 8, 9
B. Environmental quality degraded	Base condition, no change.	Short-term adverse impact on terrestrial habitat near landward toe and on levees will have effect on approximately 10 acres 1, 6, 8, 9	Same as 2-foot raise but with approximately 16 acres affected. 1, 6, 8, 9	Same as 2-foot raise but with approx. 30 acres affected; Minnesota Boat Club boathouse may be adversely affected. 1, 6, 8, 9
C. Environmental quality destroyed	Base condition, no change.	No effect.	No effect.	Minnesota Boat Club boathouse may be adversely affected 3, 5, 8, 9
3. Social well-being				
A. Beneficial impacts				
(1) Enhancement of health, safety, and community well-being	Base condition, no change.	Positive effect on health, safety, and community well-being through reduced dependence on emergency flood control for flood events in excess of existing project design levels. 1, 5, 8, 9	Same as 2-foot raise. 1, 5, 8, 9	Same as 2-foot raise. 1, 5, 8, 9
(2) Educational, cultural, and recreation opportunities	Base condition, no change.	Project modifications will encourage additional recreational development 1, 5, 8, 10	Same as 2-foot raise. 1, 5, 8, 10	Same as 2-foot raise. 1, 5, 8, 10
B. Adverse impacts				
*(1) Deterioration in quality of life, health, and safety	Base condition, no change.	None	None	None
(2) Degraded educational, cultural, and recreational opportunities	Base condition, no change.	Will cause some change in recreational opportunities when implemented in conjunction with local park plans. 1, 5, 8, 10	Same as 2-foot raise. 1, 5, 8, 10	Same as 2-foot raise. 1, 5, 8, 10
*(3) Injurious displacement of people and community disruption	Base condition, no change.	Impacts related to displacement of people and community disruption caused by floods in excess of present design would be mitigated. 3, 5, 7, 9	Same as 2-foot raise but with greater mitigation. 3, 5, 7, 9	Same as 2-foot raise but with greater mitigation. 3, 5, 7, 9
4. Regional development				
A. Beneficial impacts				
(1) Value of increased income	Base condition.	No long-range regional change. Short-range construction employment benefits provide average annual equivalent benefits of $46,800 1, 5, 8, 9	Same as 2-foot raise but with benefits of $63,200 1, 5, 8, 9	Same as 2-foot raise but with benefits of $135,000 1, 5, 8, 9
(2) Quantity of increased employment	Base condition.	Increase in short-term employment of 23 persons.	Increase in short-term employment of 33 persons.	Increase in short-term employment of 60 persons.
(3) Desirable population distribution	Base condition.	No significant regional change.	No significant regional change.	No significant regional change.
(4) Increased stability of regional economic growth	Base condition	No significant regional change.	No significant regional change.	No significant regional change.
B. Adverse impacts				
(1) Value of income lost	Base condition.	None	None	None
(2) Quantity of jobs lost	Base condition.	None	None	None
(3) Undesirable growth	Base condition.	No regional effect.	No regional effect.	No regional effect.

* Items specifically required in Section 122 and ER 1105-2-240.

Index of footnotes:

Timing

1. Impact is expected to occur prior to or during implementation of the plan.
2. Impact is expected within 15 years following plan implementation.
3. Impact is expected in a longer time frame (15 or more years following implementation.

Uncertainty

4. The uncertainty associated with the impact is 50 percent or more.
5. The uncertainty is between 10 percent and 50 percent.
6. The uncertainty is less than 10 percent.

Exclusivity

7. Overlapping entry; fully monetized in NED account.
8. Overlapping entry; not fully monetized in NED account.

Actuality

9. Impact will occur with implementation.
10. Impact will occur only when specific additional actions are carried out during implementation.
11. Impact will not occur because necessary additional actions are lacking.

Summary comparison of alternative plans

Item	No action plan	2-foot barrier raise	4-foot barrier raise	Standard project flood barrier raise
A. Plan description	Maintain status quo, allowing continued development and growth of the Riverview area. Continued dependence on emergency flood control for flood events above project design levels.	Raise level of protection of existing flood barrier by 2 feet.	Raise level of protection of existing flood barrier by 4 feet.	Raise level of protection of existing flood barrier by 8 feet.
B. Significant impacts				
1. Social effects				
*Noise	Noise will increase with continued industrial park growth.	Short-term increase during construction period. No long-term change due to barrier raise.	Same as 2-foot-raise.	Same as 2-foot-raise.
Population density	Population density in nearby residential areas expected to increase with industrial park growth.	Same as base condition	Same as base condition.	Same as base condition.
*Displacement of people	None	None	None	None.
*Aesthetic values	No change	Increase due to incorporation of project beautification.	Same as 2-foot raise.	Same as 2-foot raise.
Historic structures	Base condition.	Minnesota Historical Society indicates no impact on historical structures.	Same as 2-foot raise.	Minnesota Boat Club boathouse National Register Site may be adversely affected
Transportation	No change.	Minor raising of railroad tracks.	Some relocating and raising of railroad tracks.	Significant relocation of railroad tracks.
*Community cohesion and desirable growth	Continued development will enhance community cohesion through increased employment in central city area.	Same as base condition.	Same as base condition.	Same as base condition.
2. Economic effects				
National economic development				
Beneficial	Base condition, no benefits.	Average annual equivalent benefits of $458,100	Average annual equivalent benefits of $659,900	Average annual equivalent benefits of $849,800
Adverse	Base condition, $938,200. Average annual equivalent damages.	Average annual cost of $367,900	Average annual cost of $520,000	Average annual cost of $1,319,000
Net	Base condition	$90,200	$139,900	-$469,200
*Tax revenues	Base condition, continued growth will increase tax revenues substantially.	Same as base condition.	Same as base condition.	Same as base condition.
*Property values	Values will continue to rise as project land is developed.	Same as base condition.	Same as base condition.	Same as base condition.
*Public facilities	Public facilities such as streets, sewer, water, lighting, power, phone have been installed to most of industrial park.	Very minor changes will be needed.	Some changes necessary.	Moderate amount of changes necessary.
*Public services	Need for public services such as fire, security, road maintenance, snow removal, grass cutting will increase with continued development.	Need for emergency flood control will decrease with this option.	Similar to 2-foot raise.	Similar to 2-foot raise but at somewhat lesser cost.
*Regional growth	Base condition	No change from base condition.	No change from base condition.	No change from base condition.
*Employment(1)	Base condition.	Average annual benefits of $46,800 from barrier construction.	Average annual benefits of $63,200 from barrier construction.	Average annual benefits of $135,000 from barrier construction.
*Business and industrial activity	Continued long-term increase.	Continued long-term increase plus short-term increase during construction phase.	Continued long-term increase plus short-term increase during construction phase.	Continued long-term increase plus short-term increase during construction phase.
*Displacement of farms	None.	None.	None.	None.
3. Environmental effects				
*Man-made resources	None.	Will encourage additional recreation development in the area.	Same as 2-foot raise.	Same as 2-foot raise.
		Short-term adverse impact on recreation facilities due to reduced access during construction.	Same as 2-foot raise.	Same as 2-foot raise.
*Natural resources	Base condition	Short-term adverse impact on terrestrial habitat near landward toe and on levees. Approximately 10 acres affected.	Same as 2-foot raise but with about 16 acres affected.	Same as 2-foot raise but with about 30 acres affected.
Pollution aspects				
*Air	None	Temporary increase in air pollution during construction	Same as 2-foot raise.	Same as 2-foot raise.
*Water	None	None.	None.	None.

Summary comparison of alternative plans (cont)

Item	No action plan	2-foot barrier raise	4-foot barrier raise	Standard project flood barrier raise
C. Plan evaluation				
1. Contribution to local planning objectives				
a. Needs for additional protection within original project area	Base condition. Average annual damages of $938,200. This must be met by dependence on emergency flood control for flood events above project design levels.	Average annual equivalent benefits of $458,100. Remaining annual damages of $480,100 to be met by dependence on emergency flood control for flood events above this design level.	Average annual equivalent benefits of $659,900. Remaining annual damages of $278,300 to be met by dependence on emergency flood control for flood events above this design level.	Average annual equivalent benefits of $849,800. Remaining annual damages of $88,400 to be met by dependence on emergency flood control for flood events above this design level.
b. Compatibility of options with local plans	Existing local plans formulated on full knowledge of in-place levee construction.	Generally compatible with most local existing and future plans.	Some conflict with both existing and future plans.	Substantial conflict with both existing and future plans.
c. Present and future land uses	No conflict as land planning has been determined by protection afforded by levee.	Minimum conflict with present industrial uses.	Some conflict with present industrial uses.	Substantial conflict with present industrial uses, especially those adjacent to floodwalls.
d. Minimize local cooperation requirement - local costs	Base condition			
(1) Based on existing legislation		Lands, easements, and right-of-way $274,000	Lands, easements, and right-of-way $565,000	Lands, easements, and right-of-way $2,153,000
(2) Based on President's cost-sharing policy (City of St. Paul, State of Minnesota)		$924,000 $231,000	$1,304,000 $326,000	$3,314,000 $828,000
2. Contributions to national planning objectives				
a. National economic development (NED)				
(1) Net annual benefit	Base condition	Average annual benefits of $458,100	Average annual benefits of $659,900	Average annual benefits of $849,800
(2) Net annual cost		Average annual costs of $367,900	Average annual costs of 520,000	Average annual costs of $1,319,000
(3) Benefit-cost ratio		B/C 1.25	B/C 1.27	B/C 0.64
(4) Net NED benefits		$90,200	$139,900	-$469,200
b. Environmental quality (EQ)				
(1) Natural resources	Base condition	Short-term adverse impact on terrestrial habitat near landward toe and on levees. Approximately 10 acres affected.	Same as 2-foot raise but with approximately 16 acres affected.	Same as 2-foot raise but with approximately 30 acres affected.
(2) Air pollution	Base condition	Temporary increase in air pollution during construction.	Same as 2-foot raise.	Same as 2-foot raise.
(3) Water pollution	Base condition	None	None	None
c. Social well-being (SWB)	Continued development will enhance community cohesion through increased employment in central city area.	Same as base condition. No persons, farms, or businesses displaced.	Same as base condition. No persons or farms displaced.	Same as base condition. No persons or farms displaced. Possible dislocation of several businesses depending on further soil investigations.
d. Regional development	Base condition	No change from base condition.	No change from base condition.	No change from base condition.
3. Plan response to associated evaluation criteria				
a. Acceptability	Protected above 1-percent chance flood so complies with State and local regulations regarding flood vulnerability.	Acceptable	Acceptable	Height would encounter aesthetic objection.
b. Completeness	Designed for 168,000 cfs. Flood of record, 171,000 cfs.	Design flow of 187,000 cfs.	Design flow of 210,000 cfs.	Design flow of 260,000 cfs.
c. Effectiveness	Protected area from flood of record through freeboard.	Would protect from flow of 187,000 cfs and provide 3 feet of freeboard.	Would protect from flow of 210,000 cfs and provide 3 feet of freeboard.	Completely effective against most severe combination of flood conditions.
d. Efficiency	Base condition	Least cost option.	Median cost option.	Most costly option.
e. Certainty	Base condition	All three barrier raise plans will be certain of achieving their respective objectives.		
f. Geographic scope	----------------------------	----All plans have the same geographic scope----		
g. Benefit-cost ratio	Base condition	1.25	1.27	0.64
h. Reversibility	Base condition. No cost to reverse.	Least cost to reverse.	Second least cost to reverse.	Highest cost to reverse.
i. Stability	Base condition	Medium	Medium	Medium
4. Implementation responsibility				
a. Federal	No implementation	All design and construction administration by Corps of Engineers.	Same as 2-foot barrier raise.	Same as 2-foot barrier raise.
b. Local	No implementation	Furnish lands, easements, right-of-way and share relocations.	Same as 2-foot barrier raise.	Same as 2-foot barrier raise.

(1) Regional benefit.

* Items specifically required in Section 122 and ER 1105-2-240.

RATIONALE FOR DESIGNATION OF NED PLAN

The Principles and Standards require the designation of a national economic development plan. This plan is described as the plan which best addresses the planning objectives in a way which maximizes net economic benefits. Plan B (2-foot barrier raise) provides average annual benefits of $458,100 and average annual costs of $367,900 for a net annual benefit of $90,200. Plan C (4-foot barrier raise) provides average annual benefits of $659,900 and average annual costs of $520,000 for a net annual benefit of $139,900. Based on this comparison, plan C has the greatest amount of excess benefits over costs. Therefore, of all the plans considered, this plan is the one which best addresses the planning objectives while maximizing net economic benefits. Accordingly, plan C is designated the NED plan.

RATIONALE FOR DESIGNATION OF EQ PLAN

The Principles and Standards require the designation of an environmental quality plan. This plan is described as one which will make the most significant contribution to preserving, maintaining, restoring, or enhancing cultural and natural resources.

Examination of the table on page 42 reveals that alternative 2, removal of existing structures from the flood hazard area, or alternative 3, individually protecting structures with some removals, could result in significant net positive environmental quality benefits. However, these benefits would occur only if industries and businesses relocated into an environmentally nonsensitive area as compared with the environmentally rehabilitated evacuated area. Little control could be exercised in selection of the area for relocation. Therefore, little certainty as to the true amount of net benefits can be projected. Net environmental benefits from these alternatives could conceivably be negative.

Floodplain regulations and flood insurance, alternative 3, could result in positive environmental quality benefits if regulations were imposed before base year conditions, but this is not possible. If regulations and zoning were imposed after the base year, no environmental quality benefits could

be realized as the entire area would already be fully developed. No land would be left for environmental quality enhancement as compared to the base condition.

The alternative that best satisfies an environmental quality framework is a 2-foot raise of the existing structure with some enhancement of the floodwall. This alternative would increase flood protection in the area with minimal damage to the limited terrestrial habitat in the area. In addition, the incorporation of relief or a painting on the floodwall would greatly enhance the aesthetic appeal of the project area. There is also the possibility of some savings in cost of developing some of the proposed corridor plans, such as bike trails on the levees, if these were implemented during the levee modifications and could encourage the implementation of other components of the corridor plan currently being considered by the city of St. Paul.

RATIONALE FOR SELECTED PLAN

The selection of the best plan for providing an adequate level of flood protection for the area presently protected by the St. Paul flood control project involved comparison of the various alternatives which meet the formulation and evaluation criteria outlined in previous sections of this report. Consideration was given to environmental effects, social well-being, regional development, and national economic development.

Based on the previously presented data, plan C (alternative 7-B, 4-foot barrier raise) is the selected plan. The selection was based primarily on these factors:

a. This plan provides the maximum contribution to the National Economic Development account. The benefit-cost ratio provided by this investment level is 1.27.

b. Although this plan is not the EQ plan, the difference in the amount of grassed area temporarily disturbed by the construction process is not great enough to totally eliminate it for environmental reasons.

c. The amount of disruption that would be experienced by the businesses located adjacent to the levee would be tolerable in return for the additional protection afforded by the increased levee and floodwall heights.

As can be seen by the benefit-cost ratio of 1.27, there is good economic feasibility at this point. Based on the sensitivity analysis included in the economics appendix of this report, even with an interest rate of 9.2 percent the benefit-cost ratio would be above unity.

Compliance with Executive Orders and Memoranda

Executive Order 11988, Floodplain Mangement, 24 May 1977. - The proposed action is judged to be in compliance with Executive Order 11988. Since the project area is currently protected beyond the 1-percent chance flood level, no State or local statutes impede development in the protected area. None of the alternatives would result in encroachment on the base floodplain outside of the currently protected area.

Executive Order 11990, Protection of Wetlands, 24 May 1977. - The proposed action is judged to be in compliance with Executive Order 11990. No wetlands would be affected by any of the proposed actions. No secondary or indirect effects would accrue to these resources from implementation of the selected plan.

Executive Memorandum, Analysis of Impacts on Prime and Unique Farmlands in EIS, CEQ Memorandum, 30 August 1976. - No prime or unique farmlands are located within the impact area of any of the plans. In addition, no secondary or indirect impacts would accrue to these resources from implementation of the selected plan. Therefore, the project is judged to be in compliance with the Executive Memorandum.

Level of Protection Considerations

The selected plan would provide protection against a flood flow of 210,000 cfs with 3 feet of freeboard. This flow is about 80 percent of the Corps' estimated standard project flood flow (260,000 cfs). Current State law as defined in the 25 July 1981 letter from the Minnesota Department of Natural Resources (see appendix 3) requires flood protection in urban areas to the level of the regional flood (160,000 cfs at St. Paul) plus 3 feet of freeboard or the elevation of the standard project flood, whichever is greater. The latter criterion applies at the study area. The Department of Natural Resources, however, apparently disagrees with the Corps standard project flood discharge value and believes that a lower value might be appropriate for State regulatory purposes. As shown on plate 4-5, the current State level of protection criterion is nearly satisfied with the selected plan using the Corps derived standard project flood discharge and profile. The level of the Corps standard project flood exceeds the level of the top of the proposed barrier by about one-half foot maximum and only exceeds that level near the downstream end of the project. A modest decrease of the standard project flood (for regulatory purposes) and/or a slight increase in the proposed top of barrier elevation in the downstream reach could serve to meet State requirements. A raise in project freeboard to meet State requirements would not jeopardize project economic feasibility even if the Corps standard project flood profile were used. The Corps will be working with the State of Minnesota to resolve this difference during preconstruction planning.

Current Corps guidelines require that protection (confined level plus freeboard) be evaluated and strongly considered for urban areas where catastrophic damages would result from project failure, particularly where high flood barriers are proposed and high velocities could occur. Since all major floods at St. Paul result from snowmelt and rain runoff, and the Mississippi River is slow rising, much lead time would be available (1 week or more) before the occurrence of a flood capable of overtopping the proposed flood barrier design. The timing of the peak of past

major floods at St. Paul has been accurately predicted by the National Weather Service. No residences are protected by the existing project and although flood barriers are relatively high (about 8-feet currently, 12-feet with the selected plan) the levee is designed to fail first at the downstream end to prevent sudden failure at other barrier sections. People could leave the area by several highway and street routes should failure appear imminent. Velocities at the selected design level along the protected area would be about 2 to 3 feet per second. Because flood warning and a flood emergency preparedness plan, which will be developed during advanced study stages, would all but eliminate the potential for loss of life during rare and infrequent floods and because damages although substantial would not entirely cripple the St. Paul area, the selected design is considered to provide an acceptable level of protection under current guidelines. Protection to the standard project flood level is also clearly uneconomical with a current benefit-cost ratio of 0.64.

CONCLUSION

I find that:

a. The action proposed in the recommendation section of this report is based on a thorough analysis and evaluation of various practicable alternative courses of action for achieving the stated objectives.

b. Wherever unavoidable adverse effects are found to be involved they cannot be avoided by reasonable alternative courses of action which would achieve the congressionally specified project purpose.

c. Where the proposed action results in adverse effects, the effects are either minimized or substantially outweighed by other considerations of national policy.

d. The selected project is in compliance with Executive Orders 11988 and 11990.

e. The selected alignment was coordinated and reviewed by the Minnesota Department of Natural Resources and found to be acceptable.

Accordingly, it is my decision that the public interest would be best served by implementation of the recommended action. Also, this plan is acceptable to the city of St. Paul and the other agencies and interests associated with this study.

RECOMMENDATIONS

I recommend that the United States provide additional flood damage reduction measures at St. Paul, Minnesota, generally in accordance with the plan proposed herein, with such modifications as in the discretion of the Chief of Engineers may be advisable. The President in his June 1978 water policy message to Congress proposed several changes in cost sharing for water resource projects to allow States to participate more actively in project implementation decisions and to equalize cost sharing between structural and nonstructural flood damage prevention projects. These changes include a cash contribution from benefiting States of 5 percent of the first costs of construction assigned to nonvendible project purposes. Application of this policy to the St. Paul project would require the State of Minnesota to contribute an estimated $326,000 in cash (5 percent of the $6,519,000 total estimated project first costs of construction assigned to nonvendible project purposes based on July 1981 price levels).

The President also proposed that the present cost sharing requirements for flood damage prevention benefits be modified to require a cash or in-kind local contribution equal to 20 percent of the project first costs assignable to flood damage prevention benefits. Application of this policy to the St. Paul project would require that non-Federal interests make, in addition to the State contribution, a cash or in-kind contribution of an estimated $1,304,000 (20 percent of the total first costs of construction). In addition, non-Federal interests will be required to provide assurances satisfactory to the Secretary of the Army that they will:

a. Hold and save the United States free from damages that may result from construction and maintenance of the project, not including damages which are due to the fault or negligence of the United States or its contractors.

b. Maintain and operate the project after completion in accordance with regulations prescribed by the Chief of Engineers.

The combined non-Federal share of project costs is currently estimated to be $1,630,000 of the total first costs and $3,000 for annual operation and maintenance costs. I recommend construction authorization for the St. Paul project in accordance with the Administration's proposed cost-sharing policy.

WILLIAM W. BADGER
Colonel, Corps of Engineers
Commanding

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT. CORPS OF ENGINEERS
1135 U. S. POST OFFICE & CUSTOM HOUSE
ST. PAUL, MINNESOTA 55101

REPLY TO
ATTENTION OF:

NCSED-ER

Finding of No Significant Impact

In accordance with the National Environmental Policy Act of 1969, the St. Paul District, Corps of Engineers, has assessed the environmental impacts of the following project:

Reevaluation of the St. Paul Flood
Control Project
Mississippi River at St. Paul, Minnesota

The intent of this project is to increase the level of protection of the current flood control system for the Riverview Industrial Park area in St. Paul. The proposed project would increase the level of protection through a 4-foot raise of the existing flood barrier. The project is described in section 3.00 of the assessment. This finding of no significant impact is based on the following factors: minor and short-term impacts anticipated on fish and wildlife resources and on water quality; minor impacts on the social and cultural environment; and continued coordination with appropriate State and Federal agencies. See sections 1.00 and 5.00 of the assessment for a discussion of these impacts.

The environmental review process indicates that the proposed action does not constitute a major Federal action significantly affecting the quality of the human environment. Therefore, an environmental impact statement will not be prepared.

10 Nov 81
Date

Wm W. Badger
WILLIAM W. BADGER
Colonel, Corps of Engineers
District Engineer

ENVIRONMENTAL ASSESSMENT
ST. PAUL FLOOD CONTROL PROJECT

TABLE OF CONTENTS

ENVIRONMENTAL ASSESSMENT

1.00 SUMMARY

Major Findings and Conclusions

1.01 The St. Paul flood control project protects an industrial park area in downtown St. Paul. This study was initiated to evaluate the effectiveness of the current flood control system and to investigate measures to reduce flood damages if adequate protection is not currently provided. The following actions were evaluated during stage 3: no action, floodplain insurance and floodplain regulation, 2-foot barrier raise, 4-foot barrier raise, and 8-foot barrier raise. Investigations revealed that two alternatives are economically feasible: a 2-foot barrier raise (benefit-cost ratio = 1.25) and a 4-foot barrier raise (benefit-cost ratio = 1.27). An EQ plan would incorporate a 2-foot raise combined with a design on the floodwall exterior. This would provide increased flood protection with minimal damage to the limited terrestrial habitat and improved aesthetic appeal. The 4-foot barrier raise is identified as the NED plan because this alternative provides the maximum net benefits.

1.02 The probable impacts of a barrier raise on the socioeconomic and natural resources in the area are minor and for the most part short-term.

1.03 Based on the economic review during stage 3 and the minor nature of the impacts, a 4-foot barrier raise is recommended in the feasibility report. The recommended project will not involve the placement of fill material within the ordinary high-water mark of the river. Therefore, a 404(b) evaluation will not be prepared.

Areas of Controversy

1.04 An area of controversy that developed during stage 2 studies was concern that the implementation of a barrier raise would result in the destruction of or increased damages to the Minnesota Boat Club's boathouse on Navy Island. Further studies by the Corps determined that the recommended 4-foot barrier raise would increase flood stages at the boathouse by only 0.8 foot. Physical damages to the boathouse are not expected to be any more severe than without a barrier raise.

1.05 During the late stage public meeting it became evident that the residents of the West Side, represented by the West Side Citizens Organization (WSCO), are quite apprehensive about any plans by the city of St. Paul concerning future development of Harriet Island Park. Therefore, WSCO is very concerned about how the proposed project will affect the park area. Any extensive changes to the current use of the park, or actions perceived as promoting redevelopment of the park, will most likely be opposed by WSCO. Currently, WSCO does not appear to be opposed to raising the level of protection in the area as described in the selected plan as long as no major changes in the park's character are pursued by the city. It is important that close coordination with the WSCO and the city of St. Paul be maintained during the detailed design of the project.

Relationship to Environmental Requirements

1.06 The relationships of the detailed alternatives to the requirements of Federal environmental laws, executive orders and policies, and State and local laws and policies are summarized below:

Relationship of Plans to Environmental Requirements
(Selected plan is 4-foot barrier raise)

	Degree of compliance		
	2-foot barrier raise	4-foot barrier raise (selected plan)	SPF barrier raise
Federal Statutes			
Archeological and Historic Preservation Act, as amended, 16 U.S.C. 469, et seq.	Full[1]	Full	Full
Clean Air Act, as amended, 42 U.S.C. 7401, et seq.	Full	Full	Full
Clean Water Act, as amended (Federal Water Pollution Control Act), 33 U.S.C. 1251, et seq.	N.A.[2]	N.A.	N.A.
Coastal Zone Management Act, as amended, 16 U.S.C. 1451, et seq.	N.A.	N.A.	N.A.
Endangered Species Act, as amended, 16 U.S.C. 1531, et seq.	Full	Full	Full
Estuary Protection Act, 16 U.S.C. 1221, et seq.	N.A.	N.A.	N.A.
Federal Water Project Recreation Act, as amended, 16 U.S.C. 460-1(12), et seq.	Full	Full	Full
Fish and Wildlife Coordination Act, as amended, U.S.C. 661, et seq.	Full	Full	Full
Land and Water Conservation Fund Act, as amended, 16 U.S.C. 4601-4601-11, et seq.	Full	Full	Full
Marine Protection, Research and Sanctuaries Act, 22 U.S.C. 1401, et seq.	N.A.	N.A.	N.A.
National Historic Preservation Act, as amended, 16 U.S.C. 470a, et seq.	Full	Full	Partial[3]
National Environmental Policy Act, as amended, 42 U.S.C. 4321, et seq.	Full	Full	Full
Rivers and Harbors Act, 33 U.S.C. 401, et seq.	Full	Full	Full
Watershed Protection and Flood Prevention Act, 16 U.S.C. 1001, et seq.	N.A.	N.A.	N.A.
Wild and Scenic Rivers Act, as amended, 16 U.S.C. 1271, et seq.	Full	Full	Full
Executive Orders and Memoranda			
Floodplain Management (E.O. 11988)	Full	Full	Full
Protection of Wetlands (E.O. 11990)	Full	Full	Full
Analysis of Impacts on Prime and Unique Farmlands (CEQ Memorandum, 30 Aug 76)	N.A.	N.A.	N.A.
State and Local Policies			
Minnesota Environmental Policy Act	Full	Full	Full
Land Use Plans	Full	Full	Full

(1) Full compliance - All requirements of the Statute, E.O. or other policy and related regulations have been met.
(2) Not applicable - Statute, E.O. or other policy not applicable.
(3) Partial compliance - The recommended plan was coordinated with the Minnesota State Historic Preservation Officer. Were the 8-foot barrier raise proposed, coordination would be initiated with the Minnesota State Historic Preservation Officer and the Advisory Council on Historic Preservation.

2.00 NEED FOR AND OBJECTIVES OF ACTION

Study Authority

2.01 Authority for this study is provided by section 216, Public Law 91-611, Flood Control Act of 1970.

Public Concerns

2.02 Since the completion of the St. Paul flood control project, St. Paul has experienced two major floods exceeding the previous record flood which occurred in 1952. The extent of the current development in Riverview Industrial Park and plans for river corridor development have prompted concerns about the level of protection afforded by the existing flood control project. There are also concerns about the impacts that any modifications to the present system would have on existing development in the area or on proposed corridor plans.

Planning Objectives

2.03 The objective of this study is to review the suitability of all applicable structural and nonstructural alternatives including modification to the existing project with a view toward providing an additional level of protection that would minimize possible future damages for the Riverview Industrial Area if existing protection is found inadequate. In pursuit of that objective, care must be taken to ensure that fish and wildlife, recreation, historical, and archeological resources are not advertently destroyed and that, when necessary, such resources are preserved or mitigated.

3.00 ALTERNATIVES

Plans Eliminated from Further Study

3.01 The following plans were considered in stage 2 but not included in stage 3 planning: (1) removal of existing structures, (2) individually protecting structures, (3) channel improvement, and (4) reservoir development on the Mississippi and/or Minnesota Rivers. Alternatives 1 and 2 were eliminated because of unfavorable benefit-cost ratios and lack of public support. The reservoir development and channel improvement alternatives were dropped from further consideration because they were neither technically sound nor economically justifiable.

Without Condition (No Action)

3.02 The Riverview Industrial Park area is currently considered protected above the 1-percent chance flood level, and continued development in the area is not restricted by either State law or local ordinances. Current projections indicate that the remaining 42 developable acres will be developed by 1986. The total market value of the structures to be built is estimated at approximately $25 million.

Flood Insurance and Floodplain Regulation

3.03 If immediately implemented, this alternative would impose regulations to curtail development of the 42 developable acres in the Riverview area and the purchase of flood insurance by the existing industries. Since the project area is currently considered to be removed from the floodplain, flood insurance is not held by or required for the industries and businesses in the area. Regulation and zoning would have to be imposed by 1986 to preserve the remaining open space. This is not locally acceptable. Flood insurance would have a benefit-cost ratio of 0.91.

2-Foot Raise of Existing Barrier (Plan B)

3.04 This alternative considered raising the existing levees and floodwalls, which would increase the level of protection. The levees along the upper end of the project would be raised with the creation of a road-flanking levee. The floodwall portions could be raised by capping the existing wall with a concrete extension. The ordinary levee sections would simply be raised with additional fill and be suitably seeded. A more detailed description is outlined on pages 38 and 48 and is illustrated in plates 3-1 through 3-8.

4-Foot Raise of Existing Barrier (Plan C)

3.05 This alternative was considered the apparent optimal scale of development. The levee portions would be raised in the same manner as the 2-foot raise. The floodwall sections would be raised by construction of an additional floodwall immediately adjacent to the existing structure. This alternative is described in more detail on page 57 of the feasibility report.

8-Foot Raise of Existing Barrier

3.06 Raising the existing barrier by 8 feet would protect the project area against a standard project flood. A raise of this magnitude would require major modifications to the floodwall foundation and facilities for interior drainage and seepage control. In addition, at the downstream end it would be necessary to relocate a railroad spur track to obtain land for side slopes. A more detailed description of this alternative is presented on page 57 of the feasibility report.

EQ Plan

3.07 The 2-foot barrier raise, in conjunction with some development of the scenic and recreation potentials in the project area, constitutes the EQ plan. A 2-foot barrier raise would increase the flood protection in the area with the least amount of short-term disturbance on the terrestrial habitat in the area. Incorporating a design or relief of the floodwall would greatly increase the aesthetic appeal of the project area, thereby improving the environmental quality. A more extensive discussion of the rationale for the selection of the EQ plan is presented on page 67 of the feasibility report.

NED Plan

3.08 The 4-foot barrier raise was determined to be the NED plan, since this alternative would result in the maximum net benefits. The rationale for the designation of this alternative as the NED plan is discussed on page 67 of the feasibility report.

3.09 Based on the information and analysis presented in this assessment and in the feasibility report, a 4-foot barrier raise, coupled with some development of the scenic and recreation potentials in the project area, was selected as the preferred plan. This selection represents a mix of the NED and EQ plans. The rationale for this selection is discussed on page 68 of the feasibility report.

Comparative Impacts of the Alternatives

3.10 The table on page 42 presents a summary of the environmental impacts of each of the alternative plans. Inasmuch as the nonstructural alternatives (no action and floodplain regulation) both propose maintaining the current environmental conditions in the area, they would have no impact on the environmental quality. The probable impacts of a barrier raise on the socioeconomic and natural resources in the area are minor.

4.00 AFFECTED ENVIRONMENT

Environmental Conditions

4.01 The project was completed in 1964 and protects a 448-acre industrial and commercial district known as Riverview Industrial Park. The St. Paul Port Authority, which currently has jurisdiction over the area, reports an investment of over $41 million in public capital in the area. Existing industry employs well over 5,500 people and pays more than $1 million per year in taxes.

4.02 The area is currently considered protected to above the 1-percent chance flood level, and continued development in the area is not restricted by either State law or local ordinances. Current projections indicate that the remaining 42 developable acres will be developed by 1986. The total market value of structures to be built is estimated at approximately $25 million.

4.03 Due to the extensive industrial development, fish and wildlife resources in the immediate area are limited. The floodwall areas along the river are nearly devoid of vegetation, with a few trees and grassed levees providing limited habitat for small mammals and birds.

4.04 No rare or endangered species are evident in the area although occasional sightings of the Arctic peregrine falcon may occur in the Twin Cities area during its migration.

4.05 In this section of the Mississippi River, the bottom is composed of sand and organic sludge with little aquatic vegetation. Water quality is generally good to the Metropolitan Wastewater Treatment Plant at Pig's Eye Lake. However, there are problems with organic pollution (fecal coliforms) due to urban runoff following storms and sewer discharges.

4.06 Recreation areas in the project area include Harriet Island Municipal Park and Navy Island. The Minnesota Boat Club boathouse on Navy Island has been determined eligible for nomination to the National Register of Historic Places.

Recreation Resources

4.07 Several agencies have published recommendations concerning recreation development in the project area. The following is a review of development proposals directly affected by the flood control project.

4.08 The Great River Road master plan prepared by the Minnesota Department of Transportation, Office of Environmental Affairs, recommends land acquisition and relocation of the railroad tracks adjacent to Warner Road across the Mississippi River from the flood control project, along the Mississippi River from Sibley Street to the Reserve Street Bridge. Warner Road is to be set back from the river, creating a linear open space along the river's edge. The road will be widened to a four-lane divided parkway. The plan includes a safety rest area, with parking and a detached bicycle and pedestrian path.

4.09 The St. Paul Park and Recreation Plan, prepared by the Department of Planning and Economic Development, identifies Harriet and Navy Islands as being in need of development and recommends the following:

1. The development of a large-scale marina at Harriet Island.
2. The development of trails along the Mississippi River connected to Lilydale Park for bicycling, jogging, and cross-country skiing.
3. Expansion and development of picnic facilities.
4. The proposal to make Cherokee, Lilydale, and Harriet Island Parks into one park.

4.10 Mounds Park, although noted more as the site of Indian burial mounds, offers excellent views of the flood control project area. The plan for development calls for additional background and interpretive information to be made available.

4.11 The St. Paul Mississippi River Corridor Planning Task Force has made the following proposals relative to the St. Paul Flood Control Project, in its St. Paul Mississippi River Corridor Plan, 12 October 1977.

4.12 Harriet Island is to become a major element of the central business district open space land use system. The primary goal of this system is to provide visual relief from the central business district. Passive recreation activites are to be restored under a strong river orientation theme. These activities include a riverfront promenade, picnicking, boat beaching in the lagoon, and a full service municipal marina. Also planned is restoration of the picnic pavilion along with dredging of the marina basin, lagoon reshaping, and general landscaping. Street furniture, lighting, and directional/informational signs are to be part of the proposed development. The Riverview Industrial Area will continue to be primarily light industrial with labor-intensive operations. The proposed marina is recommended to have 300 to 350 harbor slips, a public boat launching ramp, minor repair operations, excursion boat moorage, riverboat restaurant, and required parking spaces.

4.13 A pedestrian/bicycle path is planned to go through the Harriet Island open space, under the Wabasha Street Bridge, and along the Corps of Engineers flood protection wall. The path will continue along the airport boundary downstream to Southport and will return to Northport on top of the Corps of Engineers floodwall. Path construction will make use of retaining walls and/or cantilevers to maintain a continuous path system. Plato Boulevard has been proposed to connect Harriet Island open space with the airport open space loop.

Cultural Resources

4.14 The preceding plans constitute major development proposals in the area affected by the St. Paul Flood Control Project. To date no specific plan has been implemented. The St. Paul Mississippi River corridor plan represents the most comprehensive proposal and is being reviewed by the Metropolitan Council.

4.15 On 5 July 1979 the Minnesota Boat Club was determined eligible for the National Register of Historic Places. The nomination form presented to the Heritage Conservation and Recreation Service, National Register of Historic Places, states that "The Minnesota Boat Club Boathouse on Navy Island...overlooking the Mississippi River and a developing downtown is the same building that was constructed in 1910. To this day, the building rates as one of the finest of its kind in North America." Of Spanish design, the building has several unique architectural and historical features. To better withstand the expected periodic flooding, steel reinforced concrete columns were sunk to the bedrock and support the building; the use of steel reinforcing was a novel concept at that time. The walls were constructed on tile bricks. The boathouse is home to the oldest sports club in Minnesota -- the Minnesota Boat Club. Based on its historical, social, and architectural significance, the Minnesota Boat Club boathouse was determined eligible for inclusion on the National Register of Historic Places. (See appendix 7 for further information.)

Socioeconomic Resources

4.16 The Riverview Industrial Park area is a major business center of St. Paul. Development in the area is based primarily in manufacturing, but also includes some wholesale-retail trade, office space, and public utilities. A detailed description of the economic development and employment for the area is outlined on pages 17 through 19 of the feasibility report.

5.00 ENVIRONMENTAL EFFECTS

Recreation Resources

5.01 Basically, the three plans for recreation development support continuing and expanded development in the flood control project area. Although the city of St. Paul has not yet adopted a specific plan, it is assumed that basic elements represented in all three plans will be the course of action in the future. The impacts on these developments are outlined below.

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FEASIBILITY REPORT. MISSISSIPPI RIVER AT SAINT PAUL, MINNESOTA.--ETC(U)
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5.02 The no action alternative would have a negative effect on any decision relating to the degree of recreational development this area could receive. The stronger the protection, the more support continued development would receive.

5.03 The alternative of flood insurance and floodplain regulation does not appear to have any effect on proposed development plans because of the relatively insignificant amount of land left for open development.

5.04 A barrier raise would provide additional protection to the Riverview Industrial Area which in turn would preserve the quality of proposed recreation development. A potential cost savings exists with the incorporation of proposed bicycle/pedestrian trail development with expanded floodwall construction.

5.05 Short-term negative impacts on the existing recreation facilities would result from reduced access to facilities during construction. In particular, the following impacts would occur at the St. Paul Yacht Club: temporary displacement of slips and boats, lack of access to boats during construction, loss of marina deep well, relocation of electric power, loss of pilings, and added stairs for older boating guests. Solutions to minimize these impacts during construction will be investigated during the design stage of the project.

5.06 Indirect impacts, such as to aesthetics, appear to be the greatest concern. The present view of the Industrial Park Area projects an image of riverbanks crowded with buildings and protected by sterile levees and floodwalls. Aesthetic values should be considered in any proposed design alternative, and plans should incorporate solutions to this problem.

Cultural Resources

5.07 Minnesota Boat Club Boathouse. - Only one of the alternatives reviewed in this report would affect the boathouse - the 8-foot barrier raise. The water surface at the building would be 1.1 feet higher than if the 8-foot raise were not implemented. The second floor, which was not designed to receive periodic flooding, may be adversely affected if this situation were to occur. In accordance with the procedures of the Advisory Council

on Historic Preservation, 36 CFR Part 800, paragraph 4(B), coordination was initiated and carried out with the State Historic Preservation Officer to determine whether the recommended plan (4-foot raise) would affect the boathouse. The SHPO and the Corps of Engineers have concluded that there will be no effect on this National Register Property (see correspondence in appendix 2).

Natural Resources

5.08 Considering the extensive industrial development in the area, the proposed alternatives would impose no significant impacts on the fish and wildlife resources in the area. Flood insurance and floodplain regulation would have a slight beneficial impact on terrestrial habitat (assuming regulations are imposed by 1986) by preserving the currently undeveloped open space in the area. If regulation and zoning were imposed after 1986, impacts on natural resources would be the same as with no action.

5.09 A flood barrier raise would result in some disturbance of the limited terrestrial habitat in the area on the landward toe and on the levee during construction. This would affect approximately 10 acres of grassed habitat with a 2-foot raise, 16 acres with a 4-foot raise, and 30 acres with an 8-foot raise. These effects would be short-term since the improved levees would be reseeded and returned to their current condition.

5.10 A barrier raise would result in short-term negative effects on water, air, and noise in the project area. Minor amounts of runoff and sedimentation from land areas could occur during construction. In addition, a short-term increase in noise and air pollution in the project area would occur from the operation of construction equipment.

Socioeconomic Impacts

5.11 Several businesses in the project area are located immediately adjacent to the floodwall and levee and have the most potential for incurring some impact during construction. These are: McPhillips Sweeping; McPhillips Sheet Metal and Roofing Company; Kaplan Battery; AMSCO; Technical Sealants and Adhesives, Inc.; American Hoist and Derrick Company; Pier Foundry and Pattern Shop, Inc.; Twin City Barge and Towing; and Farmland Industries, Inc.

Construction activities could result in impacts on truck loading facilities, work areas, railroads, river commodity movements and barge fleeting in the area. The level of impact would depend on the level of the barrier raise. A 2- or 4-foot raise would have relatively minor impacts, with disruption being restricted to those facilities immediately adjacent to the floodwall. An 8-foot raise would result in a more extensive disruption and the removal or relocation of a railroad spur.

5.12 Because the study area already has greater than 100-year protection, growth in the Riverview Industrial Park will continue until it is fully developed. Therefore, the no action alternative or a barrier raise will not appreciably change the investment in the area.

5.13 Two beneficial impacts would accrue from a barrier raise. Flood damages would be reduced by protection from some of the potentially damaging large flood events. In addition, Ramsey County would receive benefits as a labor market area from having construction activity within its jurisdiction. These two benefits would accrue regardless of the height of the barrier.

5.14 Implementation of floodplain regulations would result in minor beneficial effects by limiting the financial impact of those damages which would occur to the contents and structures of any new construction after the implementation of the regulations. However, since on-site expansion is one of the primary means of increasing capacity, restrictions on expansion may depress property values in the area. In Minnesota, the local government's major source of revenue is property taxes. Therefore, depressed property values on a major industrial site within the city of St. Paul could adversely affect city financing. Any adverse impacts in the areas of employment or business activity would only affect the city of St. Paul and not the metropolitan area as a whole.

6.00 AGENCIES AND PERSONS CONSULTED

6.01 The following agencies, groups or individuals were sent copies of the draft feasibility report and this environmental assessment for review and comment.

Federal

Coast Guard
Environmental Protection Agency
Federal Aviation Administration
Federal Highway Administration
Fish and Wildlife Service
Geological Survey
National Park Service
Soil Conservation Service
Advisory Council on Historic Preservation

State of Minnesota

Department of Administration
Department of Agriculture
Department of Economic Development
Department of Health
Department of Natural Resources
Department of Transportation
Minnesota State Historic Preservation Office
Pollution Control Agency
State Archeologist
State Planning Agency
Water Resources Board

City of St. Paul

Department of Finance and Management Services
Department of Public Works
Mayor's Office
Planning and Economic Development Department
Port Authority of St. Paul

Other

American Waterways Operators

Citizens League

Environmental Quality Council

Metropolitan Airports Commission

Metropolitan Council

Metropolitan Waste Control Commission

Minnesota Environmental Control Citizens Association (MECCA)

Minnesota Public Interest Research Group (MPIRG)

Minnesota Boat Club

Operation 85

Propeller Club

St. Paul Area Chamber of Commerce

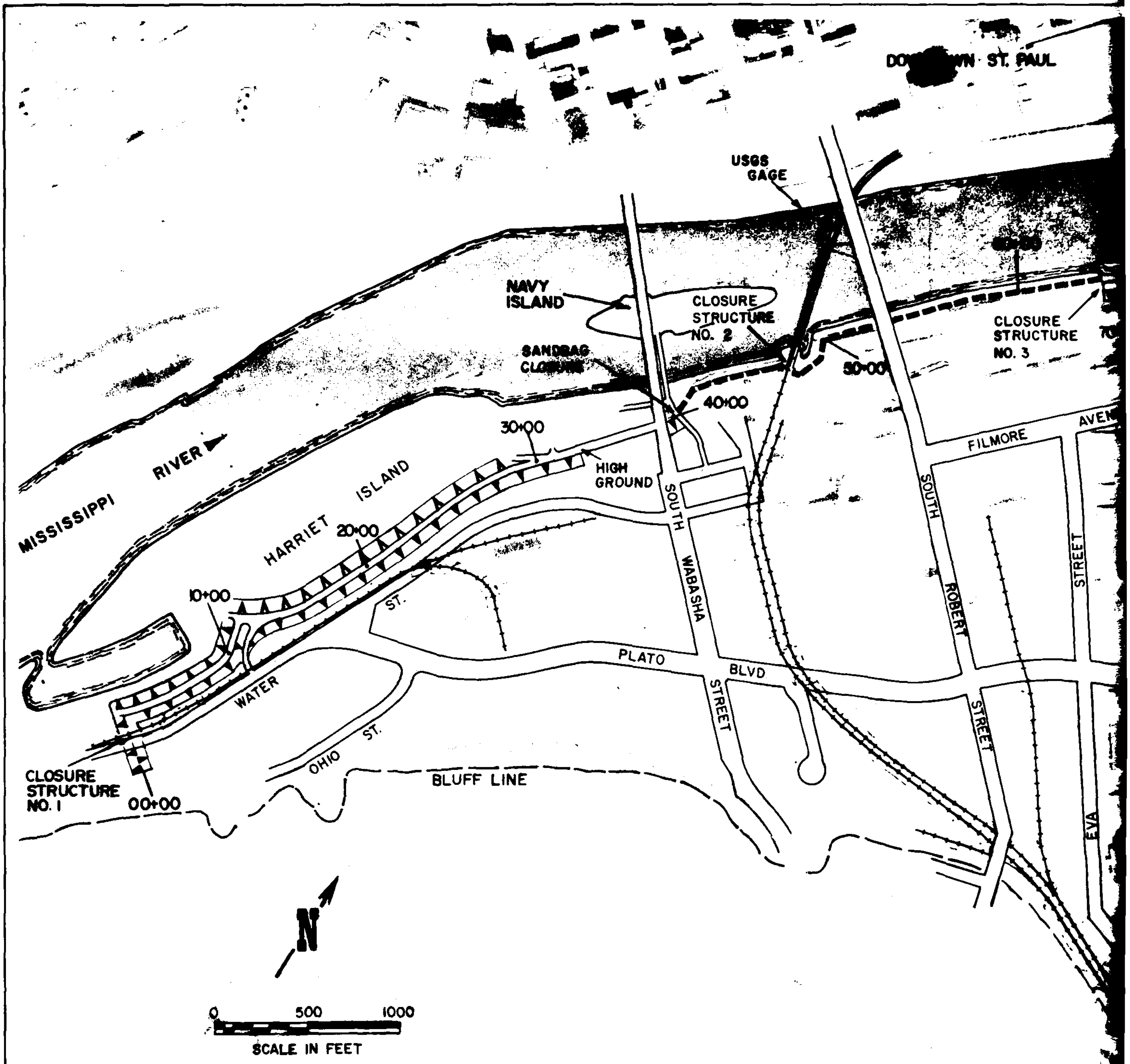
St. Paul League of Women Voters

St. Paul Yacht Club

Upper Mississippi Waterways Association

Voice of the Mississippi

West Side Citizens Organization



LEGEND

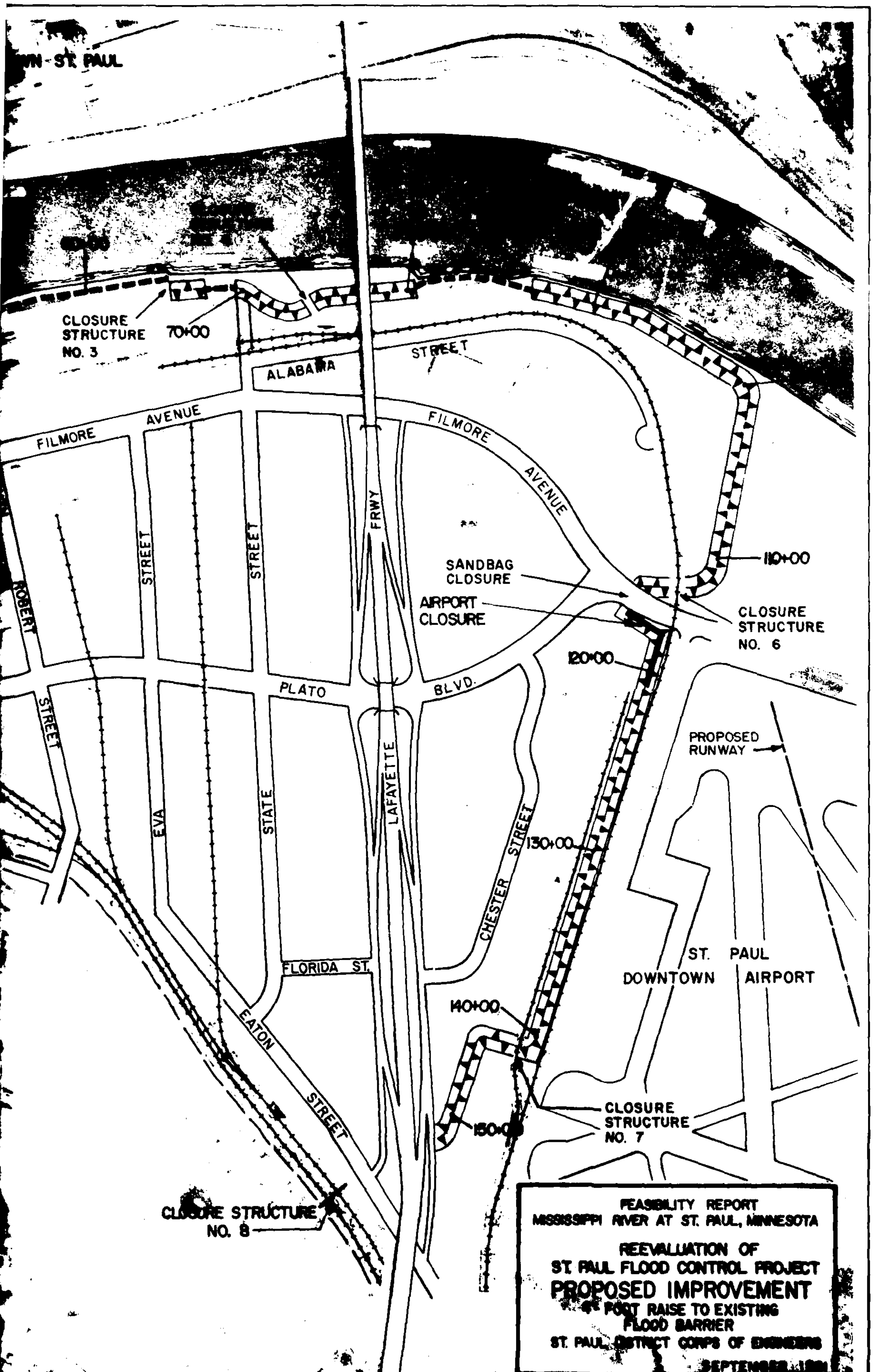
FLOOD PROTECTION LEVEE RAISE

FLOOD PROTECTION LEVEE RAISED RIVERWARD ALONG EXISTING LEVEE ROAD

FLOOD PROTECTION FLOODWALL RAISE

NOTE: THE RAISED FLOOD BARRIER ALIGNMENT FOLLOWS EXISTING PROJECT ALIGNMENT AS SHOWN.

APRIL 1980 PHOTO


ST. PAUL
CLOSURE STRUCTURE NO. 3
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ALABAMA
STREET
FILMORE
AVENUE
FILMORE
AVENUE
ROBERT
STREET
STREET
FRWY
SANDBAG CLOSURE
AIRPORT CLOSURE
110+00
CLOSURE STRUCTURE NO. 6
120+00
PLATO
BLVD.
STREET
EVA
STATE
LAFAYETTE
CHESTER STREET
PROPOSED RUNWAY
130+00
ST. PAUL DOWNTOWN AIRPORT
FLORIDA ST.
140+00
EATON
STREET
CLOSURE STRUCTURE NO. 7
150+00
CLOSURE STRUCTURE NO. 8
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REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT
PROPOSED IMPROVEMENT
FOOT RAISE TO EXISTING
FLOOD BARRIER
ST. PAUL DISTRICT CORPS OF ENGINEERS
SEPTEMBER

PLATE 1

FEASIBILITY REPORT

MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA

REEVALUATION OF

ST. PAUL FLOOD CONTROL PROJECT

PLAN FORMULATION

APPENDIX 1

ST. PAUL DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1981

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TABLES

PLATES

OBJECTIVES

The basic objectives of plan formulation are to develop a plan which will provide the best use, or combination of uses, of water and related land resources to meet all foreseeable short- and long-term needs of the St. Paul Flood Control Project area. In pursuit of this general objective, the following specific planning principles and objectives guided formulation of the plan of improvement.

a. The plan must preserve to the maximum possible extent the quality of the natural and human environment.

b. The plan must be socially acceptable.

c. The plan must enhance the economic welfare of the local people and add to their security and well-being.

d. The plan must enhance national economic development by increasing the value of the Nation's output of goods and services and improving national economic efficiency.

e. The plan must fit integrally into an overall plan for water and related land resource management and development for the Upper Mississippi River basin.

f. The plan must be technically feasible to implement.

CONSIDERATION OF THE NEEDS OF THE PROJECT AREA

Since the study authority restricts the investigation to the area protected by the existing project, this limits the options that are available for application to these needs. The needs have been addressed by completing a review of the design and operation of the present flood control works in order to make recommendations on the economic feasibility, environmental acceptability, and advisability of modifying the project or its operation due to changed economic, geotechnical, or hydrologic conditions.

ALTERNATIVE METHODS OF PROVIDING FLOOD PROTECTION

An effective and inclusive plan for providing flood protection for any area may include any combination of the known measures for flood damage reduction or prevention. Such a program would logically include one or a mix of the following nonstructural and structural measures:

a. Nonstructural measures. -

(1) Flood proofing of existing or new structures.
(2) Flood warning systems.
(3) Permanent evacuation.
(4) Flood insurance.
(5) Floodplain regulation.

b. Structural measures. -

(1) Reservoir storage.
(2) Levees and floodwalls.
(3) Channel improvements or diversions.

All of these measures were fully investigated for the St. Paul Flood Control Project.

REEVALUATION

DISCUSSION OF ALTERNATIVES

All alternatives were analyzed using the following three criteria:

a. Environmental quality. - The plan must have no irreconcilable adverse environmental impact.

b. Social well-being. - The alternative must provide a major reduction in flood damages from all sources. Only plans which offer flood protection and are supported by the public are considered socially acceptable. Relocation of residences and businesses should be minimal.

c. <u>Economic and technical feasibility.</u> - The alternative must be physically possible to implement. The sum total of tangible and intangible benefits must exceed the combined tangible and intangible costs.

d. The plan must be supported by the public.

POSSIBLE SOLUTIONS

Flood damage reduction solutions considered in this study pertain to measures needed to guarantee effectiveness of the existing project in order to insure an optimal level of flood protection for the industry located within the protected area. Both structural and nonstructural options have been addressed in considering possible alternatives. No action is generally considered a base from which to measure the desirability or feasibility of the impacts of positive alternative solutions.

<u>No Action (Alternative 1)</u>

Consideration was given to maintaining the status quo or recommending that no action be taken to raise the degree of protection provided by the existing project. This alternative constitutes the base condition from which performance of other alternatives was measured. To do nothing would not burden local interests and the Federal Government with the financial costs associated with other alternatives. Nevertheless, average annual damages estimated at over $604,000 for current conditions and $825,100 annually for 1986 fully developed (base year) conditions would remain. These damages would be a significant social and economic burden.

Because the area is currently considered protected to above the 1-percent chance flood level, continued development is not restricted by either State law or local ordinances. Barring a highly unlikely disaster, the Riverview Industrial Area is expected to grow and flourish. All parcels now undeveloped are expected to be developed within 5 years. Provisions for flood protection from major and rare floods on the Mississippi River would depend on construction of emergency levees over existing levees and placement of flashboards on existing floodwalls.

Floods on the Mississippi River in St. Paul are slow rising and can be predicted. As evidenced by the successful flood fight in 1965, when only minor damages were sustained even though the project design level was surpassed, emergency measures can be quite effective. Reliance on emergency measures can be hazardous, however, especially where a sense of security has developed due to past successful flood fights. Should emergency measures fail, damages estimated at over $100 million would occur.

Several actions have occurred or seem probable regardless of the results of this reevaluation. Any analysis of a "no action" condition will be based on the following assumptions concerning future developments.

a. The Riverview Industrial Area will continue to grow, primarily as an industrial development district.

b. Any diversity of development in the Riverview area will consist of support facilities such as restaurants and health clubs.

c. Based on past growth and St. Paul Port Authority expectations, the available vacant land will essentially be fully developed by 1986.

d. Riverfront development plans are now being prepared by the St. Paul River Corridor Task Force to meet the requirement of the critical area designation. These plans, soon to be completed, may contain the following features:

- Expansion of general navigation facilities at Harriet Island Harbor. (See main report plate 1.)
- Discontinuance of the truck unloading operation adjacent to a portion of Warner Road located on the bank across the river from the project.

- Realignment of Warner Road to allow green space and a walkway-bicycle path adjacent to the Mississippi River (approximately 10 feet in width) across the river from the project.
- Realignment of the Warner-Shepard Road, Sibley-Jackson Street intersection to allow service vehicle access and passenger loading facilities at Lambert's Landing across the river from the project.
- Unchanged maintenance of the right bank downstream of Wabasha Street.

e. Operators of the Downtown St. Paul Airport (Holman Field) will expand their capabilities by constructing a major new runway between the existing two.

Nonstructural Measures

The word "nonstructural" has been used for many years as an antonym to the word "structural" to describe alternatives to traditional Corps of Engineers projects such as dams, flood barriers, diversions, and channel modifications. Whereas structural measures act on river or tidal waters to change their direction, area of inundation, volume, stage, or timing, nonstructural measures do not. Nonstructural measures which reduce flood losses can be considered to fall into the following categories:

- Removal of damageable property from the flood hazard area.
- Individually protecting structures from flood damages.
- Zoning to prevent future flood damages and/or providing compensation through flood insurance.

In analyzing nonstructural alternatives for this study, the existing flood barriers were considered to remain in place. As the barriers provide a high level of protection, any additional protection which could be provided by nonstructural measures must first duplicate protection up to the existing project design level. In other words, the barrier would be protecting an area in which damageable property had been removed or individually protected or where losses had been insured.

Removal of Existing Structures (Alternative 2). - The Riverview Industrial Area is composed mainly of commercial and industrial buildings which, because of their size and type of construction (masonry with slab on grade floors), are not feasible to move. Rather than trying to move the structures, it would be more desirable to move the contents to a new facility in a flood-free location and tear down the existing structure or use it for some other purpose. There is no apparent use, however, for abandoned floodplain buildings and therefore the option of tearing them down appears most practical. The cost of forced relocation of the businesses and industries could conservatively be estimated to exceed $130 million, whereas capitalized flood damages prevented by such an action would be less than $13.0 million. Obviously, removal of structures from the Riverview area is not economically feasible. The city of St. Paul does not support this alternative because the more than 130 businesses in the Riverview area provide valuable city tax revenues and provide jobs for well over 5,500 area persons. In addition, many local businesses depend on output from Riverview businesses and, as such, they are a vital link in the production chain. Were the relocation forced, many businesses would likely move out of the city and possibly out of the State.

Individually Protecting Structures (Alternative 3). - Individual protection for structures in the Riverview area could be achieved by waterproofing or flood proofing, building ring-like barrier protection, or physically raising structures. Flood proofing all existing buildings is not possible because many existing structures are not designed to withstand high lateral

pressures of flooding. This plan of raising flood prone structures several feet where physically possible, removing structures which are not feasible to waterproof or raise, and/or building a levee or floodwall to protect other buildings would entail costs estimated at \$65 million. Annualized benefits would amount to \$800,000. The benefit-cost ratio would be 0.17.

Flood Insurance and Floodplain Regulation (Alternative 4). - The Riverview Industrial Area is currently considered to be removed from the floodplain or flood hazard area because the St. Paul project is considered effective under State and local laws. Since the area is considered protected to the 100-year level, floodplain regulations do not apply and flood insurance is not held by or required for industries or businesses in the area. If regulations were imposed to curtail development at this time, the 42 developable acres of vacant land in the Riverview area would remain undeveloped. This alternative, however, is not implementable, and it can be assumed that remaining vacant land would be developed by 1986.

Flood insurance could be purchased by existing industries. Flood insurance does not prevent flood damages but only assists in reimbursing affected property owners for losses sustained from flood damages. However, as pointed out by the Federal Insurance Administration, when flood insurance availability is coupled with mandatory floodplain management it is likely that long range national economic benefits will accrue.

Structural Alternatives

Channel Improvement (Alternative 5). - Channel improvement was considered as an alternative to reduce flood stages in the project area. However, preliminary analysis indicated that channel improvement would have to be continued several miles downstream even to produce a 1-foot stage reduction at the design flood discharge. An improvement of this scale would involve dredging and disposal of over 4 million cubic yards of material. The first cost of such an improvement would be about \$23.7 million. The average annual cost would be about \$2,000,000 including yearly maintenance. This plan would reduce flood damages by only about \$100,400 annually and would

have a benefit-cost ratio of 0.05. Also, since flood profiles indicate an average slope of less than 1 foot per mile in the reach under consideration, it is apparent that a raised level of protection through stage reductions attainable for any scale of channel enlargement would not justify the work, either as an alternative by itself or as a measure combined in a plan with another alternative.

Reservoir Development (Alternative 6). - Reservoir storage on the Upper Mississippi or Minnesota River could be considered as an alternative for lowering flood stages and increasing the level of protection for the existing St. Paul project. Each river drains about half of the area above the St. Paul project.

Mississippi River. - Localized flood control is provided by the natural lakes and swamps and six Corps of Engineers reservoirs in the Mississippi River headwaters area. The reservoirs, however, are capable of stage reductions in only a short reach downstream of the dams. Also, because the drainage area controlled by these reservoirs is only one-fourth of the total Mississippi River drainage above the confluence with the Minnesota River, flood control offered to the Twin Cities by these dams is minimal.

In addition to 6 Corps headwaters dams, 13 hydroelectric dams are located in the Upper Mississippi River basin above the St. Paul project. These plants are generally operated on a run-of-river basis and offer little flood control benefit. Of the three navigation locks and dams on the Mississippi River above the St. Paul project, two are used for hydropower generation. They have comparatively little available storage and operate within narrow pool fluctuation limits. Thus, they have little positive effect on reducing stages downstream.

The Corps of Engineers recommended construction of a Mississippi River Headwaters area dam and reservoir in the interim report, "Mississippi River above Coon Rapids Dam Near Minneapolis, Minnesota, Days High Landing Dam, Minnesota," dated March 1972. The project was justified in the interests of stabilizing water levels for wild rice production and for wildlife propagation but the project would not offer flood damage reduction for the Twin Cities area.

In general, conditions in the Mississippi River basin above the Twin Cities do not favor further storage development. Practically all the reservoir possibilities are broad, shallow lakes. The large change in area with comparatively small change in stage, the consequent cost of flowage and clearing, and the adverse environmental effects discourage reservoir development, especially since nearly every lake has been developed for resort purposes.

Minnesota River. - In 1966 the Corps submitted a "Phase I Feasibility Report for Flood Control and Related Purposes, Minnesota River Basin, Minnesota and South Dakota." The report found that larger-scale reservoir development would be economically feasible and indicated that reservoirs would provide substantial flood control on the Minnesota River and reduce flood stages on the Mississippi River at and downstream from the Twin Cities. The Blue Earth reservoir was one of those recommended for further study. The draft interim survey report recommending a large dam on the Blue Earth River was completed in 1970 but never released due to a lack of local and State support and strong social and environmental objections. A 1976 economic update for the Blue Earth reservoir showed a benefit-cost ratio of 0.98.

The Soil Conservation Service, cooperating with the Southern Minnesota Rivers Basin Commission, recently completed a type IV water resources study of the Minnesota River basin and southern Minnesota tributaries to the Mississippi River. The study indicated possible economic feasibility for development of 81 reservoirs in 5 subbasins of the Minnesota River. The Governor of Minnesota requested Congress to authorize the Corps of Engineers and the Soil Conservation Service to work together on an implementation study for the five subbasin area. A study under Public Law 87-639 is under way. Even with development of all 81 sites, however, stage reduction in the St. Paul area would be minimal because of the location of these reservoir sites so far upstream.

Summary. - Reservoir storage development in the Upper Mississippi River basin is not a technically sound or economically realistic way to achieve stage reductions at St. Paul. Large-scale reservoir development in the Minnesota River basin is technically possible but would have marginal economic feasibility at best and was not supported by the State of Minnesota. In addition, experience in other areas of the St. Paul District and the Nation has shown that proposals for large-scale reservoir development encounter objections by landowners, environmental interests, fish and wildlife agencies, and those concerned with preservation of natural and historic values. In many cases, by the time all objections are met, costs have increased to a point where economic feasibility becomes questionable as with the Blue Earth site. At this time it appears that reservoir development is not a viable alternative for lowering flood stages and increasing the level of protection for the existing St. Paul project.

Raising Existing Barriers (Alternative 7). - This alternative would consider raising the existing levees and floodwalls, thus increasing the level of flood protection. Any raise in this level of the top of the barrier necessitates a reanalysis of seepage and interior drainage. A review of these important factors has been completed at a level of detail suitable for a stage 3 report. These factors have been incorporated into the cost estimates and are depicted in the sketches in appendix 3. For this report the following options were considered:

a. 2-foot raise (alternative 7A). - This alternative elevation was selected for analysis because the South St. Paul project, authorized concurrently with the St. Paul project, was built with a relative level of protection 2 feet higher than the St. Paul project. Also, at the time of the 1965 flood the city of St. Paul placed an additional lift of about 2 feet along the levees and attached temporary wooden flashboards to the concrete floodwalls.

This option would be the easiest raise to implement because it is a modest increase and modifications required would be relatively simple.

The upper end of the project is topped by a high quality blacktop road. The most feasible method of raising this portion of the project appears to be the creation of a road flanking levee. The floodwall portions of the barrier could be raised by capping the existing wall with a concrete extension. The ordinary levee sections could be simply raised with additional fill and suitably topsoiled and seeded. Sketches of typical barrier sections are shown in the main report.

b. 4-foot raise (alternative 7B). - This alternative elevation was selected because it is an intermediate option between the 2-foot and standard project flood raise alternatives and because the standard project flood would be contained within the raised barrier freeboard. A 4-foot raise also appears to be the limiting raise which the concrete floodwall could tolerate without requiring redesign and major modification of floodwall foundations. The levees in open areas could accommodate an increment of this magnitude. Provisions for seepage control and interior drainage modifications would be more costly than those for alternative 7A.

c. Standard project flood raise (alternative 7C). - Standard project flood is used as an expression of the degree of protection that should be sought in flood control design where failures might be disastrous. To protect against a standard project flood would require raising the level of existing flood barriers about 8 feet. A raise of this magnitude would require major and costly modifications to floodwall foundations and facilities for interior drainage and seepage control. In addition, at the downstream end it would be necessary to relocate a railroad spur track to obtain land for side slopes.

The following table summarizes data and compares the various levels of protection provided with the incremental raises discussed above.

Comparison of existing conditions and flood barrier raises

Alternative	Design flow (cfs)	Exceedence (percent)	*Expected* occurrence (years)	Design water surface *elevation* (msl, 1912 adjustment) (2)	Freeboard (feet)(1) Above Corps of Engineers 1-percent flood	Above (4) intermediate regional flood	Above 1965 flood of record	First cost	Average annual cost (3)	Average annual equivalent damages remaining	Average annual benefits	Benefit-cost ratio
Existing conditions	168,000	0.6	167	709.7	4.6	3.6	2.6	-	-	$938,200	-	-
Alternative 7A 2-foot raise	187,000	0.3	333	711.4	6.3	5.3	4.3	$4,960,000	$367,900	480,100	$458,100	1.25
Alternative 7B 4-foot raise	210,000	0.17	588	713.3	8.3	7.2	6.2	7,000,000	520,000	278,300	659,900	1.27
Alternative 7C Standard project flood raise	260,000	0.05	2,000	717.3	12.3	11.2	10.2	17,790,000	1,319,000	88,400	849,800	0.64

(1) Freeboard is 2.8 feet for existing conditions and 3.0 feet for alternative raises above the design water surface elevation.

(2) At U.S. Geological Survey gage. For location, see Plate 1-5.

(3) Based on 7 3/8% interest, 100-year project life. Includes operation, maintenance and major replacements.

(4) For *floodplain mannagement purposes, an administratively agreed upon value of 160,000 cfs for the intermediate* regional flood is used in the St. Paul area.

NARROWING THE ARRAY OF ALTERNATIVES

Generally a final plan is recommended for implementation during stage 3 studies. Investigations are made in the detail required to determine which of several plans yields the most acceptable solution. To determine acceptability, it is necessary to evaluate the contributions each alternative makes to the specific planning objectives and the national water resources objectives. Evaluation entails a trade-off process resulting in ranking of alternatives which provides a basis for recommending further study or selecting an alternative which merits consideration as the most acceptable plan.

CONTRIBUTION OF ALTERNATIVES TO SPECIFIC OBJECTIVES

All of the nonstructural alternatives considered offer a degree of increased level of protection or reduction in possible future flood damages. The removal of existing structures from the flood hazard area (alternative 2) is by far the most effective method for reducing flood damages. However, the plan is not economically feasible and lacks support. Flood proofing also has a high potential for reducing damages but it also is not acceptable to the public in this particular instance although there are other cases where it would certainly be acceptable and beneficial. The other nonstructural measure - flood insurance - is practical. This measure would not increase the level of flood protection but would reduce future damages through the reimbursement of property owners for flood damages through insurance. This alternative may be acceptable to some. Most important, the above nonstructural alternatives do not effectively use the flood protection offered by the existing St. Paul project. The Riverview area is currently considered outside the flood hazard area by State law and local ordinances. Local people, therefore, do not see the need for and are not willing to support nonstructural flood control measures inside the area currently protected by the Corps of Engineers flood barrier.

The structural plans offer added flood protection in varying degrees. Channel improvements and reservoir development, however, are limited technically to reducing stages at the St. Paul project. The flood barrier raise appears to be the alternative which best satisfies the specific planning objectives while being supported by the publics.

The following table summarizes the economic, environmental, and social effects of the alternative plans.

Summary comparison of alternative plans

Item	No action plan	2-foot barrier raise	4-foot barrier raise	Standard project flood barrier raise
A. Plan description	Maintain status quo, allowing continued development and growth of the Riverview area. Continued dependence on emergency flood control for flood events above project design levels.	Raise level of protection of existing flood barrier by 2 feet.	Raise level of protection of existing flood barrier by 4 feet.	Raise level of protection of existing flood barrier by 8 feet.
B. Significant impacts				
1. Social effects				
*Noise	Noise will increase with continued industrial park growth.	Short-term increase during construction period. No long-term change due to barrier raise.	Same as 2-foot-raise.	Same as 2-foot-raise.
Population density	Population density in nearby residential areas expected to increase with industrial park growth.	Same as base condition	Same as base condition.	Same as base condition.
*Displacement of people	None	None	None	None.
*Aesthetic values	No change	Increase due to incorporation of project beautification.	Same as 2-foot raise.	Same as 2-foot raise.
Historic structures	Base condition.	Minnesota Historical Society indicates no impact on historical structures.	Same as 2-foot raise.	Minnesota Boat Club boathouse National Register Site may be adversely affected.
Transportation	No change.	Minor raising of railroad tracks.	Some relocating and raising of railroad tracks.	Significant relocation of railroad tracks.
*Community cohesion and desirable growth	Continued development will enhance community cohesion through increased employment in central city area.	Same as base condition.	Same as base condition.	Same as base condition.
2. Economic effects				
National economic development				
Beneficial	Base condition, no benefits.	Average annual equivalent benefits of $458,100	Average annual equivalent benefits of $659,900	Average annual equivalent benefits of $849,800
Adverse	Base condition, $938,200. Average annual equivalent damages.	Average annual cost of $367,900	Average annual cost of $520,000	Average annual cost of $1,319,000
Net	Base condition	$90,200	$139,900	-$469,200
*Tax revenues	Base condition, continued growth will increase tax revenues substantially.	Same as base condition.	Same as base condition.	Same as base condition.
*Property values	Values will continue to rise as project land is developed.	Same as base condition.	Same as base condition.	Same as base condition.
*Public facilities	Public facilities such as streets, sewer, water, lighting, power, phone have been installed to most of industrial park.	Very minor changes will be needed.	Some changes necessary.	Moderate amount of changes necessary.
*Public services	Need for public services such as fire, security, road maintenance, snow removal, grass cutting will increase with continued development.	Need for emergency flood control will decrease with this option.	Similar to 2-foot raise.	Similar to 2-foot raise but at somewhat lesser cost.
*Regional growth	Base condition	No change from base condition.	No change from base condition.	No change from base condition.
*Employment (1)	Base condition.	Average annual benefits of $46,800 from barrier construction.	Average annual benefits of $63,200 from barrier construction.	Average annual benefits of $135,000 from barrier construction.
*Business and industrial activity	Continued long-term increase.	Continued long-term increase plus short-term increase during construction phase.	Continued long-term increase plus short-term increase during construction phase.	Continued long-term increase plus short-term increase during construction phase.
*Displacement of farms	None.	None.	None.	None.
3. Environmental effects				
*Man-made resources	None.	Will encourage additional recreation development in the area.	Same as 2-foot raise.	Same as 2-foot raise.
		Short-term adverse impact on recreation facilities due to reduced access during construction.	Same as 2-foot raise.	Same as 2-foot raise.
*Natural resources	Base condition	Short-term adverse impact on terrestrial habitat near landward toe and on levees. Approximately 10 acres affected.	Same as 2-foot raise but with about 16 acres affected.	Same as 2-foot raise but with about 30 acres affect[illegible]
Pollution aspects				
*Air	None	Temporary increase in air pollution during construction	Same as 2-foot raise.	Same as 2-foot raise.
*Water	None	None.	None.	None.

Summary comparison of alternative plans (cont)

Item	No action plan	2-foot barrier raise	4-foot barrier raise	Standard project flood barrier raise
an evaluation				
1. Contribution to local planning objectives				
a. Needs for additional protection within original project area	Base condition. Average annual damages of $936,200. This must be met by dependence on emergency flood control for flood events above project design levels.	Average annual equivalent benefits of $458,100. Remaining annual damages of $480,100 to be met by dependence on emergency flood control for flood events above this design level.	Average annual equivalent benefits of $659,900. Remaining annual damages of $278,300 to be met by dependence on emergency flood control for flood events above this design level.	Average annual equivalent benefits of $849,800. Remaining annual damages of $88,400 to be met by dependence on emergency flood control for flood events above this design level.
b. Compatibility of options with local plans	Existing local plans formulated on full knowledge of in-place levee construction.	Generally compatible with most local existing and future plans.	Some conflict with both existing and future plans.	Substantial conflict with both existing and future plans.
c. Present and future land uses	No conflict as land planning has been determined by protection afforded by levee.	Minimum conflict with present industrial uses.	Some conflict with present industrial uses.	Substantial conflict with present industrial uses, especially those adjacent to floodwalls.
d. Minimize local cooperation requirement - local costs	Base condition			
(1) Based on existing legislation		Lands, easements, and right-of-way $274,000	Lands, easements, and right-of-way $565,000	Lands, easements, and right-of-way $2,153,000
(2) Based on President's cost-sharing policy (City of St. Paul, State of Minnesota)		$924,000 $231,000	$1,304,000 $326,000	$3,314,000 $828,000
2. Contributions to national planning objectives				
a. National economic development (NED)				
(1) Net annual benefit	Base condition	Average annual benefits of $458,100	Average annual benefits of $659,900	Average annual benefits of $849,800
(2) Net annual cost		Average annual costs of $367,900	Average annual costs of 520,000	Average annual costs of $1,319,000
(3) Benefit-cost ratio		B/C 1.25	B/C 1.27	B/C 0.64
(4) Net NED benefits		$90,200	$139,900	-$469,200
b. Environmental quality (EQ)				
(1) Natural resources	Base condition	Short-term adverse impact on terrestrial habitat near landward toe and on levees. Approximately 10 acres affected.	Same as 2-foot raise but with approximately 16 acres affected.	Same as 2-foot raise but with approximately 30 acres affected.
(2) Air pollution	Base condition	Temporary increase in air pollution during construction.	Same as 2-foot raise.	Same as 2-foot raise.
(3) Water pollution	Base condition	None	None	None
c. Social well-being (SWB)	Continued development will enhance community cohesion through increased employment in central city area.	Same as base condition. No persons, farms, or businesses displaced.	Same as base condition. No persons or farms displaced.	Same as base condition. No persons or farms displaced. Possible dislocation of several businesses depending on further soil investigations.
d. Regional development	Base condition	No change from base condition.	No change from base condition.	No change from base condition.
3. Plan response to associated evaluation criteria				
a. Acceptability	Protected above 1-percent chance flood so complies with State and local regulations regarding flood vulnerability.	Acceptable	Acceptable	Height would encounter aesthetic objection.
b. Completeness	Designed for 168,000 cfs. Flood of record, 171,000 cfs.	Design flow of 187,000 cfs.	Design flow of 210,000 cfs.	Design flow of 260,000 cfs.
c. Effectiveness	Protected area from flood of record through freeboard.	Would protect from flow of 187,000 cfs and provide 3 feet of freeboard.	Would protect from flow of 210,000 cfs and provide 3 feet of freeboard.	Completely effective against most severe combination of flood conditions.
d. Efficiency	Base condition	Least cost option.	Median cost option.	Most costly option.
e. Certainty	Base condition	All three barrier raise plans will be certain of achieving their respective objectives.		
f. Geographic scope	All plans have the same geographic scope			
g. Benefit-cost ratio	Base condition	1.25	1.27	0.64
h. Reversibility	Base condition. No cost to reverse.	Least cost to reverse.	Second least cost to reverse.	Highest cost to reverse.
i. Stability	Base condition	Medium	Medium	Medium
. Implementation responsibility				
a. Federal	No implementation	All design and construction administration by Corps of Engineers.	Same as 2-foot barrier raise.	Same as 2-foot barrier raise.
b. Local	No implementation	Furnish lands, easements, right-of-way and share relocations.	Same as 2-foot barrier raise.	Same as 2-foot barrier raise.

(1) Regional benefit.
* Items specifically required in Section 122 and ER 1105-2-240.

COMPARISON OF IDENTIFIED ALTERNATIVES

At this point in the feasibility study, we have identified a wide range of alternative measures and analyzed these alternatives in regard to satisfaction of the specific objectives; i.e., the reasons for the study. A selected plan of development, however, must not only address the specific objectives but also optimize contributions to the twin national objectives of national economic development and environmental quality. In order to evaluate these contributions, all alternatives were again analyzed, first in regard to national economic development and then for environmental quality. Alternatives showing the most positive net contribution to each national objective were identified.

National economic development benefits are determined by analyzing and measuring the net value of goods and services derived from each alternative. Positive contributions to national economic development are the flood control benefits credited to each alternative while negative contributions are the costs to the Nation for development of each alternative. Net contributions are the difference between positive and negative contributions and are the standard by which alternatives are compared.

As shown in the table on page 1-14, of the alternatives evaluated, alternative 7B, a 4-foot barrier raise, has the highest net benefits. Alternative 7A, a 2-foot barrier raise, has nearly identical but slightly lower net benefits. No other alternatives have net benefits approaching these two. Therefore, at this point a modest barrier raise appears to best satisfy the national economic development objective and is considered the best NED framework alternative.

Net environmental quality contributions are the basis for selection of an alternative which best satisfies the EQ objective. Examination of the table on page 1-14 reveals that only alternative 2, removal of existing

structures from the flood hazard area, or alternative 3, individually protecting structures with some removals, could result in significant net positive environmental quality benefits. However, these benefits would occur only if industries and businesses relocated into an environmentally nonsensitive area as compared with the environmentally rehabilitated evacuated area. Little control could be exercised in the selection of the area for relocation. Therefore, little certainty as to the true amount of net benefits can be projected. Net environmental benefits from these alternatives could conceivably be negative.

Floodplain regulations and flood insurance, alternative 3, could result in positive environmental quality benefits if regulations were imposed before base year conditions, but this is not possible. If regulations and zoning were imposed after the base year, no environmental quality benefits could be realized as the entire area would already be fully developed. No land would be left for environmental quality enhancement as compared to the base condition. All other plans investigated decrease environmental quality attributes.

Based on the above discussion it is difficult to label a plan as that which best satisfies the environmental quality objective. Since no alternative would offer net positive benefits with any certainty, an alternative which is least damaging might be considered as that best satisfying this objective. Using this reasoning, no action might thus be suggested as the alternative best satisfying the criteria of an environmental quality framework. However, it was decided that of the action plans the 2-foot raise was the most desirable from the standpoint of environmental quality.

SUMMARY AND DISCUSSION

All of the alternatives analyzed provide some degree of satisfaction to specific objectives. However, several of the alternatives do not satisfy other considerations of the study or fail to meet evaluation criteria.

Alternative 2 (remove structures) and alternative 3 (individually protecting structures) are unacceptable to the local people. Alternative 5 (channel improvement) and alternative 6 (reservoir development) are likely to be unacceptable to the State of Minnesota. Only alternatives 7A and 7B (raising the flood barriers) have positive net benefits and a positive benefit-cost ratio, thus satisfying the national economic development objective. Alternative 6 (reservoir development) and alternative 7C (standard project flood barrier raise) are marginal and do not provide positive economic benefits.

Environmental quality impacts are severely negative for alternatives 5 and 6. Net environmental benefits of most other alternatives are marginal, being slightly negative or positive.

FORMULATION OF SCALE OF DEVELOPMENT

To permit selection of the optimum economic level of flood damage reduction for the St. Paul Flood Control Project, costs and benefits were evaluated for three degrees of flood protection that would be provided by varying the design flood discharge for the flood control project. Analysis of the 2-foot, 4-foot, and 8-foot (standard project flood) raises determined that the optimum relationship between average annual costs and benefits is achieved at the 4-foot raise, which is at an estimated recurrence interval of once in about 588 years. An increase in the level of protection to the standard project flood level would be very difficult to implement as it would entail complete removal of much of the existing in-place protective works in order to construct the heavier sections mandated by design requirements that are more severe than those in effect when the project was originally constructed. Also, this standard project level would require the city to provide additional lands for the substantially wider levee sections. Purchasing or condemning the necessary lands would impose severe limitations on the business properties located adjacent to the barrier and in some instances would require complete removal which would make this option locally unacceptable. Finally, the benefit-cost ratio of 0.6 clearly indicates that the standard project flood raise is economically infeasible.

The following table gives economic data for various flood barrier raises.

Plan optimization data

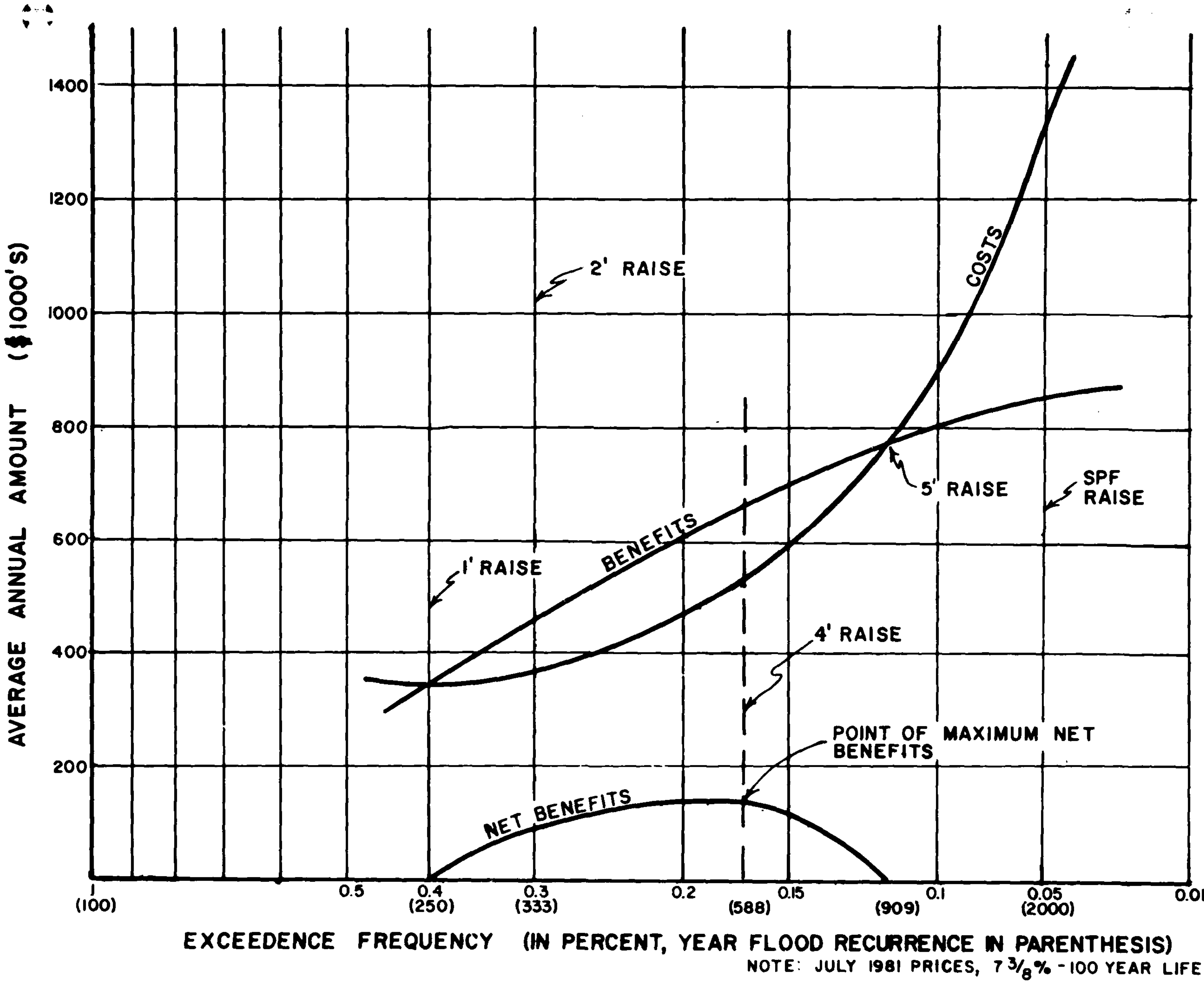
Plan	Degree of protection (in percent)	Annual benefits	Annual costs	Net benefits	Benefit-cost ratio
1-foot raise	0.4	$347,100	$346,000	+$1,100	1.00
2-foot raise	0.3	458,100	367,900	+90,200	1.25
4-foot raise	0.17	659,900	520,000	+139,900	1.27
5-foot raise	0.11	774,900	773,000	+1,900	1.00
8-foot (SPF) raise	0.05	849,800	1,319,000	-469,200	0.64

These data are depicted on two graphs (see plates 1-1 and 1-2). The first graph relates the level of protection to average annual costs and benefits. From this, a net benefits curve was derived by subtracting average annual benefits from costs at various levels of protection. Maximum net benefits occur at the selected design (4-foot raise). Zero net benefits occur approximately at the 1-foot and 5-foot raise designs. This indicates that raising the flood barrier less than 1 foot is not worthwhile, whereas raising the barrier up to 5 feet is economically justified at current prices and an interest rate of 7 3/8 percent and 100-year project life.

The sensitivity of net benefits and project optimization was tested using an 8.0-percent interest rate, current price levels, and a 100-year economic life. Benefits are rather insensitive to increasing interest rates because most project benefits are developed by the base year (1986) condition with little growth thereafter. Costs, however, are directly related to interest increases. The above factors tend to raise the cost curve vertically and very slightly lower the benefit curve vertically. Net benefits are thus reduced, and the points of zero net benefits are nearer to the optimum level of protection. Results of this analysis show that, at an

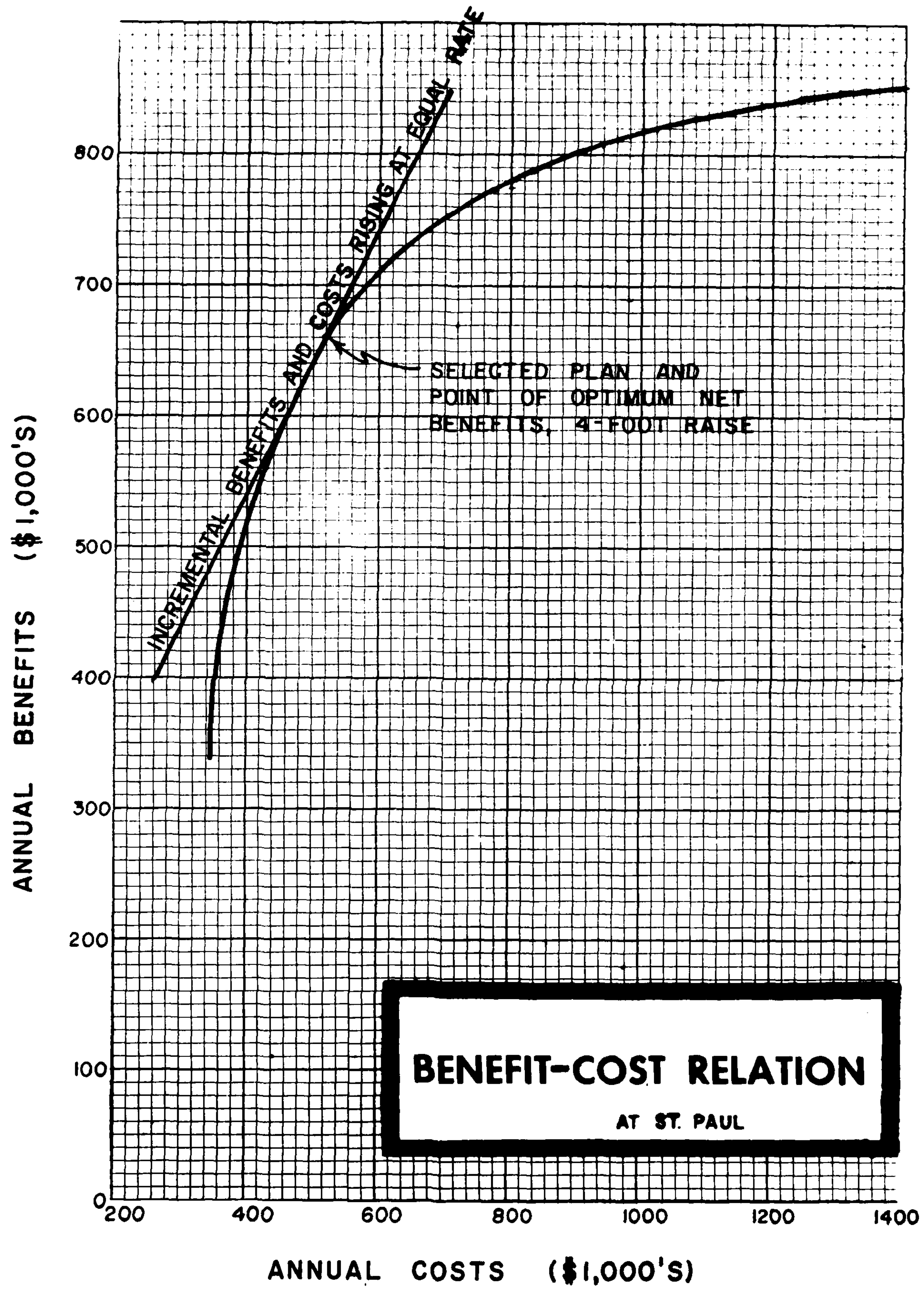
8-percent interest rate, the optimum level of development would be a 3.3-foot raise (0.2-percent flood). Points of zero net benefits would occur with a 2.5-foot raise (0.35 percent) and a 4.4-foot raise (0.13 percent). As shown in appendix 5, the internal rate of return for the selected plan (4-foot raise) is 9.2 percent.

The second graph shows average annual benefits and costs graphed on linear scales. Maximum net benefits on the graph are shown to be the point at which benefits and costs are increasing incrementally at the same rate. Again, this graph shows the point of optimum net benefits at the selected level of development.



AVERAGE ANNUAL AMOUNT ($1000'S)
1400
1200
1000
800
600
400
200
COSTS
BENEFITS
NET BENEFITS
1' RAISE
2' RAISE
4' RAISE
5' RAISE
SPF RAISE
POINT OF MAXIMUM NET BENEFITS
1 (100)
0.5
0.4 (250)
0.3 (333)
0.2
(588)
0.15
(909)
0.1
0.05 (2000)
0.01
EXCEEDENCE FREQUENCY (IN PERCENT, YEAR FLOOD RECURRENCE IN PARENTHESIS)
NOTE: JULY 1981 PRICES, 7 3/8% - 100 YEAR LIFE

PLATE I-1


INCREMENTAL BENEFITS AND COSTS RISING AT EQUAL RATE
SELECTED PLAN AND POINT OF OPTIMUM NET BENEFITS, 4-FOOT RAISE
BENEFIT-COST RELATION
AT ST. PAUL
ANNUAL BENEFITS ($1,000'S)
ANNUAL COSTS ($1,000'S)
0
100
200
300
400
500
600
700
800
200
400
600
800
1000
1200
1400

FEASIBILITY REPORT

MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA

REEVALUATION OF

ST. PAUL FLOOD CONTROL PROJECT

PUBLIC VIEWS AND RESPONSES

APPENDIX 2

ST. PAUL DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1981

PUBLIC VIEWS AND RESPONSES

GENERAL

Over the period of the study effort, formal and informal communication has been maintained with all interested Federal, State, and local agencies and private interests. Participation has been solicited during all stages. However, due to the noncontroversial nature of the study, the responses by interested publics have been almost entirely neutral.

The agencies and organizations that have been contacted for input are listed below.

Federal

Coast Guard
Environmental Protection Agency
Federal Aviation Administration
Federal Highway Administration
Fish and Wildlife Service
Geological Survey
National Park Service
Soil Conservation Service

State of Minnesota

Department of Administration
Department of Agriculture
Department of Economic Development
Department of Health
Department of Natural Resources
Department of Transportation
Historical Society
Pollution Control Agency
State Archeologist
State Planning Agency
Water Resources Board

City of St. Paul

Department of Finance and Management Services
Department of Public Works
Mayor's Office
Planning and Economic Development Department
Port Authority of St. Paul

Other

American Waterways Operators
Citizens League
Environmental Quality Council
Metropolitan Airports Commission
Metropolitan Council
Metropolitan Waste Control Commission
Minnesota Environmental Control Citizens Association (MECCA)
Minnesota Public Interest Research Group (MPIRG)
Minnesota Boat Club
Operation 85
Propeller Club
St. Paul Area Chamber of Commerce
St. Paul League of Women Voters
St. Paul Yacht Club
Upper Mississippi Waterways Association
Voice of the Mississippi
West Side Citizens Organization

PUBLIC INVOLVEMENT PROGRAM

Since study initiation, most public involvement has been the result of feedback from review of the stage 1 and stage 2 report documents and the draft feasibility report. Numerous informal meetings were held with local interest groups and the local sponsor. Because the improvements proposed were not controversial and would have minimal impact on the community, only one official public meeting was held.

The late stage public meeting concerning the proposed project was held on 13 August 1981. Nine persons other than Corps of Engineers personnel were present. Meeting notices were sent to over 150 persons/businesses/groups/agencies. Notice of the meeting was published in a local paper. Representatives from the city of St. Paul, the Minnesota Department of Natural Resources, the West Side Citizens' Organization (WSCO), the St. Paul Yacht Club, and the local neighborhood newspaper were present.

The city spokesman, representing the mayor, stated qualified support for the project. However, city assurances that it would sponsor the project were held in reserve, primarily because of the city's uncertainty about local costs for the project and hesitancy to commit future funds for the local project share. Further discussions revealed the city's plan to rebuild a road along Harriet Island, a feature that was not part of the project plan. The road cost and higher than reported estimates for real estate acquisition were the main reasons for differences in the Corps and city estimates. The cost sharing policies of the Corps were discussed in detail.

WSCO had concerns about the effects of the project on Harriet Island Park. They questioned the need for the project and showed concern over high project costs and the necessity for relocating businesses (no relocations are required with the proposed plan). WSCO was neutral regarding the project as a whole.

A representative of the St. Paul Yacht Club made a statement. The Yacht Club operates a small harbor on Harriet Island near the upstream end of the project. The spokesman was concerned that city and Corps' plans be coordinated and that boaters' needs and Yacht Club concerns be taken into account.

A citizen saying that he represented the West Side community (the project area is in what is called the West Side of the city of St. Paul) made a statement. His concern was that Harriet Island Park might be lost to the community if the plans of the city of St. Paul are implemented (these are park redevelopment plans having nothing to do with the Corps proposal).

Two letters were read into the record. The first was a 13 February 1981 letter from the St. Paul Department of Public Works, which is included in this appendix. It stated concerns regarding existing and proposed project details. The second was a letter from American Hoist and Derrick Company which supports the project. This company asked that consideration be given to rebuilding the new and higher floodwall riverward of the existing wall near their final assembly area and test yard. This letter is also included later in this appendix.

The representatives of the Minnesota Department of Natural Resources made no official statement on behalf of his agency.

COMMENTS OF OTHER AGENCIES AND INTERESTS

This section presents the views and comments of other Federal agencies and non-Federal interests with discussion pertinent to the recommended improvements for the existing St. Paul flood control project. Comments and responses are included for letters received during stage 3. Those letters are also attached. Pertinent correspondence received prior to stage 3 is included at the end of this appendix.

Comments during stage 3 were received from the following:

a. American Hoist and Derrick Company

Comment - American Hoist believes that the level of flood protection should be increased. Because of space restrictions, American Hoist would prefer the floodwall modifications to be riverward of the existing floodwall.

Discussion - Modifications have been made to the project plans presented in the draft feasibility report. Floodwall modifications south of Robert Street along the area of concern will be along the riverward side of the existing floodwall, and this change is reflected in this feasibility report.

b. Federal Aviation Administration

Comment - The Federal Aviation Administration stated its concerns regarding the adequacy of airport runway clearances should the existing flood barrier be raised.

Discussion - We have coordinated this concern with the Metropolitan Airports Commission. Our correspondence regarding the clearance zone question is included later in this appendix. In summary, the Corps has modified plans for the barrier raise for a section of levee where clearances are critical. A "notch" will be left in the raise at that point and clearances will be maintained. In the event of a very large flood, this notch will be closed with sandbags. The airport would be closed during times of flood, and the sandbags would not interfere with airport operations at those times. The sandbags would be removed promptly after flooding recedes.

c. Soil Conservation Service

Comment - The Soil Conservation Service had no comment on the draft Feasibility Report.

d. St. Paul Yacht Club, Harriet Island

Comment - The Yacht Club agrees that the 4-foot raise is most favorable. The St. Paul Mississippi River Corridor Plan, which was being developed under the administration's National Investment Strategy, was questioned. Portions of that plan were included under "Plans of Others" in the draft feasibility report. Negative impacts of constructing the levee raise in the area of the Yacht Club boat harbor, especially abandonment of the road in that area, were not addressed.

Discussion - Comments regarding the River Corridor Plan have been addressed in this report, and appropriate revisions have been made to pages referred to in the Yacht Club's letter. The plan for a road flashing levee proposed in the draft feasibility report in the area adjacent to the Yacht Club has been modified. Abandonment of the road was only considered with a standard project flood barrier raise. The plan presented in this report for the selected 4-foot raise considers raising the roadway adjacent to the Yacht Club. Impacts of that plan have been included in the environmental assessment (paragraph 5.05).

e. Mayor, City of St. Paul

Comment - The city encourages development and improvement of existing facilities to accommodate projected demands and extend their useful life. The city believes that both structural and nonstructural measures in combination would be the best alternative. Two major concerns include the impact of the project on Harriet Island Park and the city's share of the local cost. The city's floodplain ordinances would have to be revised when the project is completed.

Discussion - In the interim between completion of the draft feasibility report and this report, numerous meetings were held with the Divisions of Planning and Parks and Recreation to better explain the plan presented in the draft report and define obligations of the city associated with the plan.

Slight changes in alignment were made to better satisfy city objectives. Impacts on Harriet Island are minimal with the proposed plan, and continued coordination with the city will be maintained during future planning to ensure that desires of the city are taken into account during finalization of preconstruction plans. Nonstructural plans such as flood warning and emergency protection were discussed in these meetings. Other nonstructural measures, i.e., flood proofing, floodplain zoning, and relocation, are clearly impractical in an area which is already protected to a 167-year level. The city agrees that the selected plan is best for the project area and has written a letter supporting the proposed plan which is included in this appendix. The Corps will assist the city in modification of the Floodplain Ordinance if modifications are required with project implementation.

f. National Weather Service

Comment - Some of the facts concerning climate on page 11 of the draft feasibility report are incorrect.

Discussion - The feasibility report has been modified to include the suggested revisions.

g. Fish and Wildlife Service

Comment - The Fish and Wildlife Service agrees with the issuing of a Finding of No Significant Impact.

h. Environmental Protection Agency

Comment - The EPA has no comments beyond those already submitted in an earlier letter. That letter agreed that environmental impacts would be minimal.

i. St. Paul Department of Public Works

Comment - The Department of Public Works had three basic comments. First, the switching mechanisms at existing pumping stations are obsolete. Second, closure structure number 8 (the far downstream end of the project) could be shortened. Third, the Moses Street and Custer Street pumping stations must be modified with a project raise because they are located outside of the barrier line of protection.

Discussion - The switchgear used at these pumping stations is not the type which is currently used. The Corps is evaluating whether the switchgear problem constitutes a project deficiency and whether replacement is a cost which the Corps should bear. Closure structure number 8 has been modified as suggested for the proposed plan. Costs for providing new concrete parapet walls around ventilators and access doors were included in the draft feasibility report and are included in this report.

j. Minnesota Department of Natural Resources

Comment - Along with many specific comments regarding flood insurance and floodplain regulation, the Minnesota Department of Natural Resources raised the major issue of whether the project modification was needed because adequate flood protection is already provided by the existing project. A question regarding project mitigation was also raised.

Discussion - Specific comments have been addressed as appropriate in this report. The Corps is aware of the opportunities for environmental enhancement associated with the project, particularly in relation to public use development. However, mitigation measures for wildlife are not considered necessary, based on the nature and duration of the anticipated impacts. A 4-foot barrier raise would affect approximately 16 acres of grassed habitat tat on the landward toe of the levees during construction. These effects would be short term since the improved levees would be reseeded. The U.S. Fish and Wildlife Service agrees with this determination.

Our 29 May 1981 letter responding to the above comments is included in this appendix. The Department of Natural Resources' response dated 15 July 1981 is also included. In its response the Department implies support for a project raise. The official letter of State support is included in this appendix.

k. Port Authority of St. Paul

Comment - The Port Authority found that the 4-foot barrier raise will have no adverse effects on Riverview Industrial Park lands.

l. Minnesota Department of Health

Comment - The Minnesota Department of Health was concerned that water wells be protected from surface flooding to prevent groundwater contamination.

Discussion - With the proposed plan of improvement, wells in the protected area will be protected from Mississippi River flooding to the level of a 0.17-percent chance flood (588-year flood).

m. Corps of Engineers to Minnesota Department of Natural Resources

The attached letter is the St. Paul District's response to the previously referred to letter of the Department of Natural Resources. It outlines the Corps' views concerning the added level of protection issue. It also states the need for State support of any proposed improvements.

n. Corps of Engineers to Metropolitan Airports Commission

The St. Paul District requested views on closures required to maintain clearances for existing and proposed runways at the St. Paul Downtown Airport.

o. Metropolitan Airports Commission

Comment - The Metropolitan Airports Commission concurs with the Corps' analysis of clearances required and agrees that leaving a low spot in the levee which would be closed with sandbags or earth during rare flood events is an acceptable plan.

p. Minnesota Department of Natural Resources

Comment - This letter responded to the Corps' 29 May 1981 letter. The Department's response implies support for a raise in the level of flood protection at St. Paul in order to meet current State criteria.

q. American Hoist and Derrick Company

Comment - This letter was in response to announcement of the public meeting. Again American Hoist stated its support for a flood barrier raise and its wish to have the floodwall modifications along a portion of its property.placed on the riverward side of the existing floodwall.

Discussion - Plans have been modified and the floodwall raise is now proposed along the riverward side of the existing wall in the area of concern. During future studies and preconstruction planning, the Corps will coordinate closely with American Hoist to ensure compatibility of project designs with American Hoist's clearance needs.

r. City of St. Paul

Comment - The letter provides necessary assurances that the city will support the project recommended in this report.

s. Minnesota Historical Society

Comment - The State Historic Preservation Officer responded to the St. Paul District's request to review the impacts of the proposed barrier raise on the Minnesota Boat Club, a property that has been determined eligible for inclusion on the National Register. The analysis indicates that the project will will have no effect on the Minnesota Boat Club.

Discussion - The coordination culminating with the letter fulfills Corps responsibilities concerning project effects on historic sites eligible for or included in the National Register.

t. Governor of Minnesota

Comment - The Governor concurs that the plan presented in this report is the most feasible alternative and supports congressional authorization for the plan. However, the State of Minnesota questions the applicability of President Carter's 1978 cost-sharing policy.

amhoist AMERICAN HOIST & DERRICK COMPANY

CROSBY-AMERICAN PROPERTIES Inc.

KURT WILLIAMSON
VICE PRESIDENT GENERAL MANAGER

January 15, 1981

Colonel William Badger
CORPS OF ENGINEERS
1135 U.S. Post Office & Customs House
St Paul, MN 55101

REFERENCE: St Paul Flood Control Feasibility Report

Dear Colonel Badger:

In response to your December 31, 1980 letter and Feasibility Reevaluation Report of the St Paul Flood Project, American Hoist & Derrick Company agrees that the flood wall should be increased.

The flood of 1969 and especially 1965 caused severe concern that our facility, which employs approximately 1850 people and has a large investment in real as well as personal property, would be in great danger. Complete shutdown was a near reality.

We have discussed the feasibility of wall height increase with the Corps before and have some concerns that we wish to make you aware of. The increasing of that wall landward of the river would cause American Hoist extreme problems.

Our operation involves heavy equipment manufacturing and the flow of our finished product, as well as new developments, involves movement from final assembly to the north and parallel with the flood wall to our test yard (map attached). Clearance out of our building and along the flood wall is about at the minimum at present. With increased height of the wall as proposed, the

TELEPHONE: (612) 228-4215

distance between the building and wall would be shortened and could pose impossible restrictions. This problem needs to be reviewed in future studies.

We will cooperate in any way possible and feel that this is a viable project to us as well as to all others in the Riverview Industrial Park.

Please call at your convenience.

Sincerely,

Kurt Williamson
Vice President &
General Manager

/jg

att.

Enc. 900 Series Equipment Catalog
& Lifting Ratings for 9310

cc: F Bremer
D Nordstrand
R Sandford

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Airports District Office
6301 - 34th Avenue, South
Minneapolis, Minn

January 21, 1981

Colonel William W. Badger
District Engineer
Department of the Army
St. Paul District, Corps of Engineers
1135 U. S. Post Office & Custom House
St. Paul, Minnesota 55101
Attention of: NCSED-PB

Dear Colonel Badger:

Our office has reviewed the Draft Feasibility Report, Reevaluation of St. Paul Flood Control Project, dated December 1980. Our primary area of concern regarding the report lies in the areas of the approaches to runways at the St. Paul Downtown Airport. In the event that one of the barrier raise plans (2, 4, or 8 foot) is adopted we would request review of the plans in the runway approach areas for adequacy of clearance.

We wish to thank you for the opportunity to review the draft report.

Sincerely,

Donald R. Stockdale
State Program Officer

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

200 Federal Bldg., 316 No. Robert St., St. Paul, MN 55101

January 22, 1981

Colonel William W. Badger
District Engineer
Dept. of the Army
St. Paul District, Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota, 55101

Attention: NCSED-PB

Dear Colonel Badger:

We have reviewed the draft Feasibility Report Mississippi River at St. Paul, Minnesota, and have no comments to offer at this time.

Thank you for the opportunity to review this document.

Sincerely,

Harry M. Major
State Conservationist

SAINT PAUL **YACHT CLUB** HARRIET ISLAND
SAINT PAUL, MINNESOTA 55107
Telephone: 222-9874

28 January 1981

Colonel William W. Badger
District Engineer
St. Paul District Corps of Engineers
1135 U. S. Post Office & Custom House
St. Paul, Mn. 55101

Dear Colonel Badger,

Thank you for the opportunity to review the Dec. 1980 report on the St. Paul Flood Control Project.

In reviewing the alternatives discussed in the report, I agree with the recommendation favoring the four (4) foot increase in the levee height. A four foot increase will provide needed protection without the problems and conflicts of the higher eight foot option. The potential benefits to St. Paul industry as well as to St.Paul parks and boating makes this a very worthwhile project.

The following comments are offered for consideration:

pg.23- "7 acre marina" is not presently part of the critical river plan-- but it could very well be a better answer to an expanded marina capacity.

pg.31-"At present the city's plan infringes on portions of the levee..." -- the city plan must be developed and proven compatible with the levee plan as well as needs of the park and marina. Present plans have not worked out problems of space for:

1. Athletic fields
2. Back channel location
3. 350 car parking near 350 boat slips
4. Winter storage near water and lift
5. Roads to move boats behind flood wall for floods
6. Minimize hill/stairs between cars and boat slips.

pg.39 What is the cross section of a road flanking levee? Parking for boaters is very important and should not be sacrificed for a road flanking levee.

pg. 49,50,55 Negative impacts to Harriet Island are not addressed:

1. Temporary displacement of slips and boats
2. Lack of access to boats during construction
3. Loss of marina deep well
4. Relocation of electric power
5. Loss of pilings
6. Added stairs for older boating guests

pg.58- Abandonment of road on top of the levee will make the harbor unusable as a marina unless other parking is provided.

Sincerely,
Frank Kline

Frank W. Kline
Director, SPYC
6321 Stevens Ave So
Minneapolis, Mn 55423

CITY OF SAINT PAUL
OFFICE OF THE MAYOR

347 CITY HALL
SAINT PAUL, MINNESOTA 55102
(612) 298-4323

GEORGE LATIMER
MAYOR

February 5, 1981

Colonel Forrest T. Gay, III
District Engineer
Corps of Engineers
1135 U. S. Post Office
Saint Paul, Minnesota 55101

Re: Feasibility Report: Reevaluation of Saint Paul
Flood Control Project; NCSED-PB
Metropolitan Council File #4488-2

Dear Colonel Gay:

The City of Saint Paul appreciates the opportunity to review and comment on the 1980 draft of the Flood Control Project Feasibility Report. As we have pointed out in the past, both the City and private business have made a considerable investment in the Riverview Industrial Park and it is certainly in the public's best interest to see that the area under study is adequately protected from flood damage. Since our review of the 1978 draft of the project, Saint Paul has adopted The River Corridor Plan as official City policy. Specifically, the Plan states "...federal agencies will be encouraged to improve existing facilities to accommodate projected demands and extend their useful life." This remains a clear reference to the Corps' anticipated project improvements.

We compliment you on your reevaluation of alternatives. We were particularly gratified to see that our recommendation was followed and that Upstream Floodplain Regulation was examined. We were disappointed, however, in the selection of a purely structural alternative. We still feel that a structural solution combined with acceptable non-structural components is the best alternative.

Given your selection of Plan C (4-foot barrier raise), we would like to comment on two major concerns the City has regarding the effect of this project on Harriet Island Park:

First of all, the selected 4' raise (alternative 7B) as illustrated on cross section plates would impact the physical accessibility and general atmosphere of the park environment. This impact could be very positive if treated properly. The Corps states on page 31, "Ongoing discussions are exploring all possibilities for cooperation between the City and the Corps in regard to implementation of these two overlapping plans." The City of Saint Paul, Division of Parks, shares the Corps' desire to avoid overlapping plans. We feel that there is great potential for enhancement of the recreational

experience at Harriet Island. Cooperation between the Corps and the City on planning and design is essential to both the floodwall and the park, and must be a contingency attached to City approval/recommendations of the Flood Control Project.

Secondly, as stated on page 56 of the draft, the City of Saint Paul, the local sponsor, would be required to "provide all lands, easement and rights-of-way necessary for the placement of the improvements." It is not clear at this time what land would be involved; therefore, no commitment should be made regarding land, easements and rights-of-way until the City and the Corps have developed an agreeable site specific plan for the Harriet Island area. It should be understood, however, that any increase in the floodwall height implies an increase in the amount of land needed.

Due to the proximity of the project to the park, the Division of Parks and Recreation should be apprised of the continuing status of the project and become a part of the planning and design process.

The project, when completed, will have the immediate effect of forcing Saint Paul to reevaluate and amend the Floodplain Ordinance. We would expect the Corps to provide technical and financial assistance in the completion of this substantial task.

Finally, as noted in our review of the 1978 draft, the Saint Paul Zoning Ordinance requires a Floodplain Conditional Use Permit for any structural improvements to the floodwall or the levee.

Thank you again for this opportunity to comment on this important issue. We cannot stress too strongly that we feel close coordination between the Corps and the Divisions of Planning and Parks is essential to the development of a successful project.

Sincerely,

George Latimer

George Latimer
Mayor

cc: James Bellus
Peggy Reichert
Robert Sprafka
Robert Piram

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE Forecast Office
Federal Aviation Building
6301 34th Avenue South
Minneapolis, Minnesota 55450

February 10, 1981

Department of the Army
St. Paul District Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Col. Badger:

Regarding your draft feasibility report on the Re-evaluation of St. Paul Flood Control Project, December 1980, the following errors were in the climate section on page 11: In the third paragraph on the third line "8:03 inches for May 1962" should read "9.31 inches for August 1977". On the fourth line same paragraph "26 inches" should read "27 inches" and the mean annual snowfall is now "46.5 inches" rather than "42.5 inches".

Otherwise, your report appears to be correct.

Sincerely,

John V. Graff
Meteorologist in Charge (AM)

United States Department of the Interior

FISH AND WILDLIFE SERVICE
TWIN CITIES AREA OFFICE
530 Federal Building and U.S. Court House
316 North Robert Street
St. Paul, Minnesota 55101

IN REPLY REFER TO

FEB 11 1981

Colonel William W. Badger
District Engineer, St. Paul District
U.S. Army Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Badger:

This provides our comments on the draft feasibility report and draft environmental assessment on the reevaluation of the St. Paul Flood Control Project.

We agree with your proposal to issue a finding of no significant impact on this project with respect to possible biological impacts. As we indicated in our early coordination letter, we do not anticipate significant impacts to fish and wildlife resources to result from implementation of the preferred alternative.

Sincerely yours,

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION 5
230 SOUTH DEARBORN ST
CHICAGO ILLINOIS 60604

REPLY TO ATTENTION OF

1 FEB 1981

Colonel William W. Badger
District Engineer
U.S. Army Engineer District, St. Paul
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 551

RE: NCSED-PB

Dear Colonel Badger:

We have completed our review of the Draft Feasibility Report for Reevaluation of the St. Paul Flood Control Project, Mississippi River at St. Paul, Minnesota dated December 1980. The report contains a draft environmental assessment.

We have no additional comments to add to those already expressed in our March 22, 1979, letter on the Draft Preliminary Feasibility Report for this activity (a copy of this letter is found on page 2-38 in Appendix 2 of the current document). We continue to anticipate minimal environmental impacts from the proposed action.

We appreciate the opportunity to review this report. Further matters relevant to this project should be referred to Rick Pitorak of my staff at 312/886-6689.

Sincerely yours,

Barbara J. Taylor

Barbara J. Taylor, Chief
Environmental Impact Review Staff
Office of Environmental Review

CITY OF SAINT PAUL
DEPARTMENT OF PUBLIC WORKS

DONALD [illegible] DIRECTOR

[illegible] MER
MAYOR

[illegible]

[illegible]
[illegible] Engineer
[illegible]
[illegible] and [illegible]tom House
[illegible], [illegible]sota 55101

[illegible] Feasibility Report Mississippi River at St. Paul, [illegible]
[illegible] of St. Paul Flood Control Project.

[illegible] Radiner:

[illegible] reviewed the December, [illegible] Draft of the above report [illegible] would like to [illegible] the following comments.

1. The entire starting switch mechanisms for the Moses Street, Custer Street and Chester Street pumping stations are now obsolete. We already have been unable to get some replacement parts. It takes a long time for these parts to be specially made. If these parts or any number of other parts in the starting switches should fail during a flood it could mean real trouble. We feel that you should bring this equipment up to date as soon as possible.

2. Closure Structure #8 is a very long railroad closure structure. It is very difficult for us to install this structure in the early spring when the ground is frozen. Most of the sets of railroad tracks at this location have now been removed and we feel that when you upgrade this structure you should also shorted it as much as possible.

3. In the last paragraph on Page 4-22 it is stated that the Moses Street and Custer Street pumping stations are located within the protected area. Actually these two pumping stations are located on the river side of the flood protection. Both of these stations therefore have a door and a ventilator that are subject to the flood waters. This problem should be looked into and corrected before the flood wall is raised any further.

Sincerely,

[illegible]

[illegible]
Manager, [illegible] and Utilities

[illegible]

cc: Donald F. Nygaard
Gary [illegible]chson

STATE OF
MINNESOTA
DEPARTMENT OF NATURAL RESOURCES

BOX 32, CENTENNIAL OFFICE BUILDING • ST. PAUL, MINNESOTA • 55155

DNR INFORMATION
(612) 296-6157

FILE NO. ______________

February 19, 1981

Colonel William W. Badger
District Engineer
St. Paul District Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, MN 55101

Dear Colonel Badger:

Thank you for the opportunity to review the draft feasibility report "Re-evaluation of St. Paul Flood Control Project". This report has been reviewed by the Division of Waters and the Division of Fish and Wildlife. A number of questions and concerns were identified during the review process.

One question that comes to mind when reading the report is why it was deemed necessary to re-evaluate this project at this time. The project successfully protected the Riverview area from the flood of record in 1965 even though this flood exceeded the design stage of the project and there was still apparently in excess of two feet of freeboard at peak discharge.

The project as designed protects the Riverview areas from the 0.6 percent chance flood event with three feet of freeboard. Although federal regulations prohibit the inclusion of freeboard in the determination of the level of protection, freeboard does in fact provide additional protection. In this case it appears as though the freeboard might be sufficient with appropriate emergency measures to protect the area from approximately a 400-year frequency flood event. It is difficult to question increased protection if provided at federal expense but this raises questions of priorities particularly regarding other Minnesota communities which have no flood protection at all.

Additional comments on specific portions of the report areas are as follows:

Page 27, 2nd paragraph. Some floodproofing measures could be implemented in new construction to provide additional protection from extremely rare flood events.

Page 28, 1st paragraph. The planning objective for this study is to provide an "acceptable level of protection" . . ."if adequate protection is not now provided". It appears as though the existing project does provide an acceptable level of protection.

Page 28, last paragraph. "This alternative would be more appropriately called "Status Quo" or "Existing Situation". It is obvious from the description of the alternative that a number of actions are involved.

Page 33, 2nd paragraph. It is unclear what types of emergency measures are being referred to. Some standard operational procedures are needed for all significant floods on a project such as this because of the road closures. Are the emergency measures being referred to additional protective measures taken during the 1965 flood, or are they over and above the standard operational procedures needed to guarantee normal levee operation.

Page 35, 1st paragraph. This area has been determined to be outside of the 100-year flood plain so neither the state law nor the local flood plain management ordinance currently applies to this area. Even if the state and local laws did apply, development could be regulated but could not be curtailed. As long as structures are elevated above the protection elevation or floodproofed, development of this area could proceed.

Page 35, 2nd paragraph. The benefit cost ratio for Alternative 4 should be thoroughly documented. It is frequently difficult to demonstrate economic feasibility for non-structural measures. It is possible that Alternative 4 should not even be included because the area is not considered to be within the 100-year flood plain.

Page 37, last paragraph. The P.L. 87-639 study being conducted in the Minnesota River Basin will take in excess of 10 years to complete.

Page 42. There are several apparent errors in the description of Alternative 4. In the category "Plan Description" mandatory flood insurance is discussed. Currently only lending institutions can require flood insurance on mortgaged properties. In the category "Economic Impacts" benefits are listed as $111,800 while costs are listed as $333,500. These figures would not result in net benefits of $19,000 or a benefit cost ratio of 1.21. In the "Environmental Impacts" category, the 66 acres of currently undeveloped land could still be developed as long as it is elevated or floodproofed. In the category "Response to Evaluation Criteria" it should be specified that many non-structural measures are generally ineffective in reducing damages to existing structures.

Page 44, 3rd paragraph. Alternative 4 has the highest net benefits according to the table on Page 42.

Page 45, 2nd paragraph. The reference should be to Alternative 4 not Alternative 3. Flood plain regulations as they currently exist would not prevent development even if they were applicable to the area behind the existing project.

Page 46, 1st paragraph. Flood insurance and flood plain regulation are not required because this area has been determined to be outside of the 100-year flood plain. These measures might however provide additional protection to new development from extremely rare flood events. Alternative 4 also has positive net benefits according to the table on Page 42.

Page 50, 1st paragraph. An application for a Public Waters Permit would be required from the local sponsor in order to enlarge the harbor.

Page 51, 2nd paragraph. It is uncertain at this time whether any mitigation measures would be required or not. There are certainly opportunities to enhance the environment and to provide some limited wildlife habitat in the project area. What agencies and disciplines were represented on the interdisciplinary team that determined that no mitigation is necessary?

Page 51, 4th paragraph. Until Congress acts to change the current cost sharing requirements, it is assumed by the State of Minnesota that the proposed cost sharing formula does not apply. It should be pointed out that the changes were proposed by President Carter.

Page 67, 1st paragraph. Alternative 4 (flood plain regulation and flood insurance) has the highest net benefits according to the table on Page 42 and should be designated as the NED plan.

Page 67, last paragraph. The alternative referred to is Alternative 4 not 3. Flood plain regulation would not prohibit development of the area even if the regulations were applicable in an area determined to be outside the 100-year flood plain.

Page 70, 2nd paragraph. This conclusion is misleading. It should state "Significant future flood damages can be expected to occur if a flood greater than the design standard of the project should occur during the effective life of the project. It is also questionable whether a project with a benefit cost ratio of 1.02 can be considered economically feasible, particularly when some of the assumptions are examined in detail.

Page 71, 1st paragraph. Flood insurance and flood plain regulation were not evaluated in the section entitled "Assessment and Evaluation of Detailed Plans" beginning of Page 46. This alternative is also economically feasible according to the table on Page 42.

Page 73, last paragraph. Flood plain regulations would not necessarily curtail development even if the area was located in the 100-year flood plain.

Page 81, 4th paragraph. It is stated that flood plain regulations would result in minor beneficial effects but on Page 1-7 the benefits are listed as $81,800 annually. This is about 17% of the average annual damages.

Page 4-6. A number of different discharges have been used to describe the 1% chance flood at St. Paul. Do these varying determinations (150,000 cfs vs. 160,000 cfs) affect the design flood elevation?

Page 4-7, 1st paragraph. Are the increases in water surface elevation due to increases in the amount of fill riverward of the existing levee and floodwall? At what discharge do these increases occur?

Page 5-1, 2nd paragraph. The assumption that major flood damages begin at the design flood elevation is a questionable assumption and appears to be an attempt to increase the net benefits of the project. It is quite obvious from the 1965 flood experience that major damages can be averted above the design flood elevation. Levee dependability can never be absolutely assured so it seems interesting that the project freeboard which is built with the same materials and to the same standards as the floodwall and levee below the design flood elevation can not be assumed to provide some additional level of protection.

Page 5-2, 1st paragraph. It is difficult to believe that damages caused by overtopping the levee could increase from $27,229,000 to $69,400,000 over a one year period of time. Even with very high rates of growth, expansion, and inflation, this is a tremendous increase in damages in one year!

Page 5-3, 2nd and 3rd paragraph. Earlier references in the report were to 66 acres not 38 acres of developable land. Which number is correct? This would also affect the value determinations in the 3rd paragraph.

Page 5-12. Future developments could also reduce the economic feasibility of the selected plan. Another stretch of recession conditions could prevent or postpone some of the new development projected for the area. It is also highly unlikely that interest rates will come down. It seems more likely that interest rates will continue to go up.

In summary it appears that the existing project does provide what is generally considered an adequate degree of protection from flooding in the Riverview area. It is encouraging to see the Corps reviewing the adequacy of existing flood control projects but we question whether enhancement of this project can be justified when other communities that desire flood protection in the State do not warrant any federal investment whatsoever under existing policies. Unquestionably, any requests for State financial participation in project enhancement will raise these questions of priority in a public forum.

Thank you again for the opportunity to comment on the report. I assume that these comments will assist you im making changes in the draft report. If you have any questions related to this project, please contact Mr. Joseph Gibson of my staff at (612) 296-0438.

Sincerely,

DIVISION OF WATERS

Larry Seymour
Director

LS/JG:cnt

cc: Joseph Alexander, Commissioner
Kent Lokkesmoe, Regional Hydrologist, Metro
Ronald Harnack, Supervisor, Land Use Management Section

PORT AUTHORITY OF THE CITY OF SAINT PAUL
25 WEST FOURTH STREET • SUITE 1305 • ST. PAUL, MINN. 55102 • PHONE (612) 224-5686

February 26, 1981

Colonel William W. Badger
District Engineer
Department of the Army
St. Paul District Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

RE: FEASIBILITY REPORT
REEVALUATION OF ST. PAUL
FLOOD CONTROL PROJECT
NCSED-PB

Dear Col. Badger:

The Port Authority has reviewed the draft feasibility report on the reevaluation of the St. Paul Flood Control project and find that the 4-foot barrier raise will have no adverse effects on the adjacent lands in Riverview Industrial Park.

Yours truly,

Robert F. Sprafka
Executive Vice President

RFS:ca

minnesota department of health
717 s.e. delaware st. minneapolis 55440
612 296 5221

March 2, 1981

Colonel William W. Badger
District Engineer
U.S. Army Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Badger:

Thank you for the draft of "Feasibility Report, Mississippi River at St. Paul, Minnesota, Re-evaluation of St. Paul Flood Control Project, December 1980."

As was stated in our letter of February 22, 1979, the Minnesota Department of Health has concerns about water wells in flood protected areas, because of the possibility of contamination to the ground water through flooded water wells. The Department is of the opinion that flood protection of water wells in these areas should be given a high priority. Such protection would include the identification and sealing of all abandoned wells, and the flood protection of active wells. It would appear to be helpful to also consider the private wells at the nearby St. Paul (Holman Field) Airport in the planned flood control project.

We appreciate the opportunity to have received the draft of your report, and ask that the protection and abandonment of water wells be given your consideration in flood areas under study.

If you have further questions please contact either Roman Koch, Jim Nye or Ed Ross at 296-5338.

Sincerely yours,

Roger L. DeRoos

Roger L. DeRoos, Ph.D., Director
Division of Environmental Health

[illegible] 2[illegible] May 1981

Mr. Larry Seymour
Director
Division of Waters
Minnesota Department of Natural Resources
Box 32
Centennial Office Building
St. Paul, Minnesota 55155

Dear Mr. Seymour:

This is in reference to your 1[illegible] February 1981 letter commenting on the draft feasibility report, "Reevaluation of the St. Paul Flood Control Project," dated [illegible]ember 19[illegible].

The items you discussed raise a question in my mind concerning your support for any flood barrier raise proposed by the Corps for the St. Paul flood control project. Although the project has withstood a flood that exceeded its design and, if freeboard could be considered, protection would be greater, the consequences of barrier failure during rare severe floods would be disastrous.

The 1965 flood is the largest known flood at St. Paul. As the report states, this flood was about 2.3 feet below the top of the barrier. During that flood, additional flashboards and temporary raises to the floodwall and levee were installed. These measures were deemed necessary because a larger flood could have and nearly did occur. There is also serious concern about the safety of the barrier had the flood encroached on the flashboards. It is possible that the barrier could have failed before flashboards were overtopped.

The discharge of the 1965 flood at St. Paul was measured at 171,000 cubic feet per second on 16 April. This discharge was made up of a major contribution from the Minnesota River drainage and a lesser amount from the Mississippi River drainage which had not yet crested during the peak at St. Paul. The Mississippi drainage crested less than 1 week later. If both rivers had contributed their maximums, a discharge of about 211,000 cfs would have been recorded in 1965. This would have overtopped the flood barrier by over 1 foot and caused over $7[illegible] million in damages under current conditions and price levels.

Development behind the flood barrier has surpassed all estimates made before construction. Because of this high level of development and associated high [illegible] risk, the St. Paul flood control project was selected for restudy.

NCSED-PB 29 May 1981

Mr. Larry Seymour

The city of St. Paul supports our study efforts and improvements to existing facilities. A copy of its 5 February 1981 letter of comment on the report is attached.

As we have found in the past with Corps projects/studies, State support is necessary. Without State support, a Corps project generally is not possible because this District will not recommend it for construction. Before our request to the Governor for an official State position, we believe a meeting to discuss the proposed project would be helpful. Mr. Al Bjorkquist, 725-7494, study manager, will contact you and make the necessary arrangements.

Sincerely,

WILLIAM W. BADGER
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

CF w/cy of 19 Feb 81 DNR ltr:
Honorable George Latimer
Mayor of St. Paul
347 City Hall
St. Paul, Minnesota 55102

NCSED-PB 5 June 1981

MR. Nigel Finney
Minneapolis -SSt. Paul
Metropolitan Airports Commission
P.O. Box 1700
Twin City Airport, Minnesota 55111

Dear Mr. Finney:

Reference is made to your recent telephone conversations with Mr. Al Bjorkquist in regard to runway clearances required at the St. Paul Downtown Airport as they are affected by the proposed raise of the St. Paul Flood Control Project.

We have reviewed the "Airport Layout Plan," sheet 3 of 13, dated 10/23/75, which you sent. Inclosed is a tabulation showing the clearance ratios with the proposed 4-foot levee raise in place. Assuming our calculations are correct, the raise would not violate the MDA 40:1 criteria except in two instances:

1. Existing airport configuration, runway 12, in the clear zone south of Bayfield Street.

2. Proposed airport configuration, runway 14, in ultimate clear zone, south of Bayfield Street.

Either case affects about 500 feet of levee where the raise is proposed. This area is shown in red on the overlay (inclosure22).

In our final feasibility report which is scheduled for completion in July 1981 we intend to propose that the levee in the area affected (shown in red on inclosure 2) remain at the present elevation, All other levee sections would be raised 4 feet. The "low spot" in the levee would be filled with a sandbag closure or earth fill during extreme flooding. This procedure should not affect airport operations because during these periods the runways would be flooded and the airport would be closed. The closure would be removed promptly when flooding recedes and before the airport reopens.

NCSED-PB 1 June 1981

Mr. Nigel Finney

We request your views on the above proposal. If you feel further coordination is needed before your response, please call Al Bjorkquist (725-7494), project manager.

Sincerely,

2 Incl
As stated

LOUIS KOWALSKI
Chief, Planning Branch
Engineering Division

5 MAY 1981
A

ST. PAUL DOWNTOWN AIRPORT

(1) RUNWAY NUMBER	(2) EXISTING TO REMAIN w/EXPANSION	(3) EXISTING [illegible] w/EXPANSION	(4) PROPOSED w/EXPANSION	(5) 1/ ELEVATION AT END OF CLEAR ZONE	(6) 2/ DISTANCE TO LEVEE FROM PT (5)	(7) REQUIRED ELEVATION @ LEVEE 1:20	(8) REQUIRED ELEVATION @ LEVEE 1:40	(9) EXISTING LEVEE ELEVATION	(10) 4-FOOT RAISE LEVEE ELEVATION	(11) 3/ CLEARANCE ABOVE 1:20 CONSTRAINT	(12) 3/ CLEARANCE ABOVE 1:40 CONSTRAINT	(13) 3/ CLEARANCE RATIO
8	X			700.0±	870	743.5	721.8	711.2	715.2	28.3	6.6	57:1
12	X			703.7±	330 (PT.A) 4/ 550 (PT.B) 4/	720.2 731.2	711.9 717.5	711.2 711.2	715.2 715.2	5.0 16.0	-3.3 2.3	27:1 48:1
			X	704.3±	1360 (PT.A) 5/ 1580 (PT.B) 5/	772.3 783.3	738.3 743.8	711.2 711.2	715.2 715.2	57.1 68.1	23.1 28.6	125:1 145:1
14			X	703.0±	560 (PT.B) 5/ 250 (PT.A) 5/ 6/	732.0 715.5	717.5 709.3	711.2 711.2	715.2 715.2	16.8 0.3 6/	2.3 -5.7 6/	48:1 20:1
16		X		703.7±	1000	753.7	728.7	711.2	715.2	38.5	13.5	87:1

FOOT NOTES:

1/ ELEVATIONS ASSUMED TO BE USGS 1929 ADJ., ALL LEVEE ELEVATIONS ARE ADJUSTED TO THE 1929 DATUM

2/ MEASURED FROM "AIRPORT LAYOUT PLAN" SHEET 3 OF 13, 10/23/75, METROPOLITAN AIRPORTS COMMISSION

3/ CONSIDERS 4-FOOT RAISE IN PLACE

4/ EXISTING RUNWAY CONFIGURATION, PT.A. IS THE POINT ON LEVEE SOUTH OF BAYFIELD NEAREST TO (5), PT.B. IS POINT ON LEVEE NORTH OF BAY FIELD NEAREST TO (5)

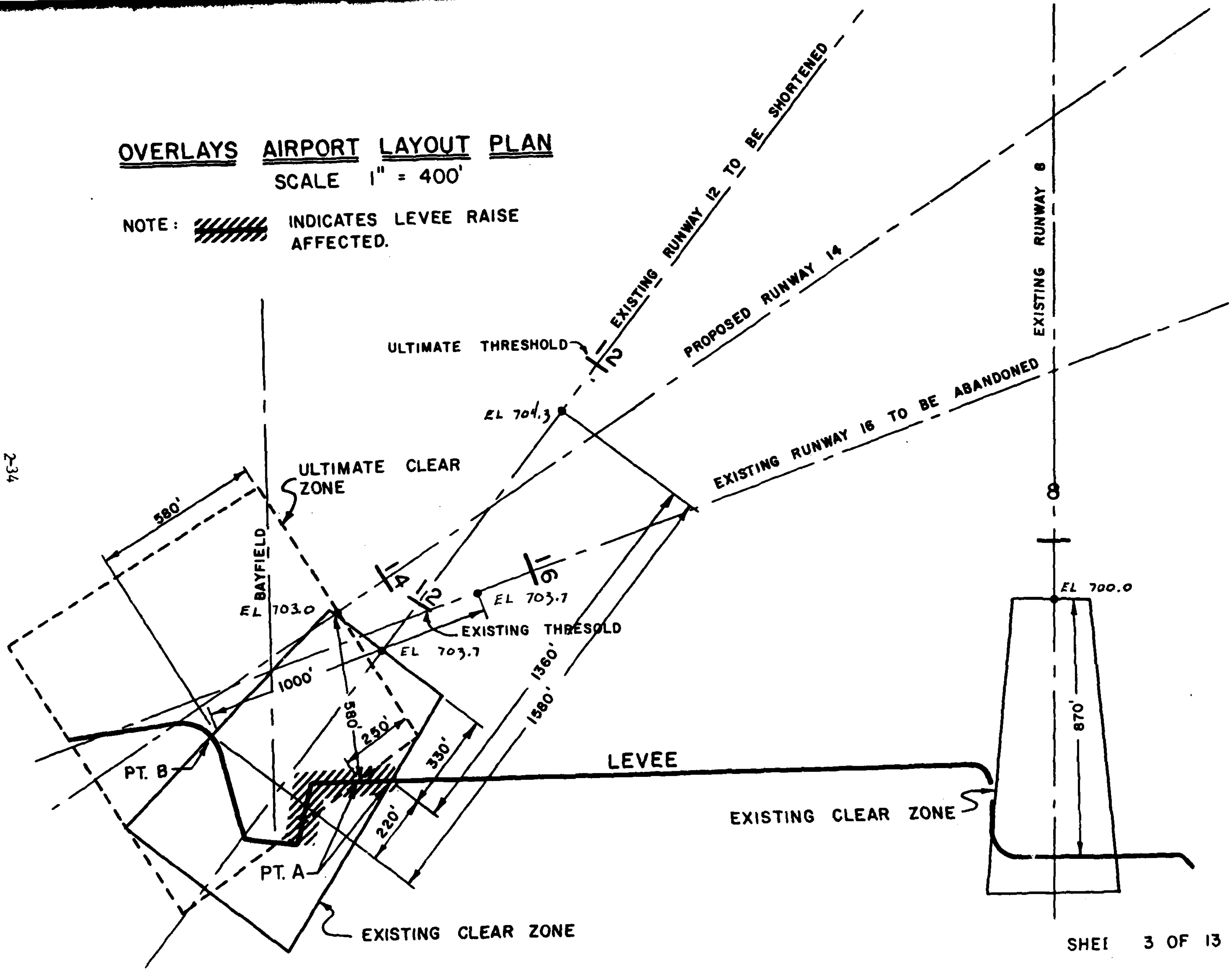
5/ PROPOSED RUNWAY CONFIGURATION, PT.A AND PT.B AS DESCRIBED IN 4/ ABOVE.

6/ ASSUMES MEASUREMENT FROM ULTIMATE CLEAR ZONE LINE AS IN (5) ABOVE PARALLEL TO ℄ OF PROPOSED RUNWAY. IF MEASUREMENT IS TAKEN FROM INTERSECTION OF CLEAR ZONE AND ℄ OF RUNWAY 16, DISTANCE WOULD BE 580 FEET ((6)) AND (13) [illegible] 1:40

OVERLAYS AIRPORT LAYOUT PLAN

SCALE 1" = 400'

NOTE: (hatched symbol) INDICATES LEVEE RAISE AFFECTED.



SHEI 3 OF 13

Minneapolis • Saint Paul
METROPOLITAN AIRPORTS COMMISSION
P. O. BOX 1700 • TWIN CITY AIRPORT • MINNESOTA 55111

OFFICE OF EXECUTIVE DIRECTOR • PHONE (612) 726-5770

June 26, 1981

Mr. Lewis Kowalski
Chief - Planning Branch
Engineering Division
St. Paul District
Corp of Engineers
1135 U.S. Post Office & Custom House
St. Paul, MN 55101

Dear Mr. Kowalski:

MAC Staff has reviewed your letter of June 5, 1981 with regard to the impact of the St. Paul Flood Control Project on St. Paul Downtown Airport. We concur with your analysis of the impact on clearances to runways 14 and 12 of the increased elevation of the levee. The approach of leaving a "low spot" in the levee to be filled with either sand bags or earth during extreme flooding seems to be a practical and realistic approach to maintaining appropriate clearances to the airport.

Feel free to contact this office should you have any additional questions or concerns regarding this issue.

Sincerely yours,

Nigel D. Finney

Nigel D. Finney
Director of Planning & Engineering

/jr

STATE OF
MINNESOTA
DEPARTMENT OF NATURAL RESOURCES
BOX 37, CENTENNIAL OFFICE BUILDING • ST. PAUL, MINNESOTA • 55155

DNR INFORMATION
(612) 296-6157

FILE NO. ______________

July 15, 1981

Colonel William W. Badger
District Engineer
St. Paul District Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, MN 55101

Dear Colonel Badger:

This will acknowledge your letter of May 29, 1981 with regard to the feasibility report re-examining the flood control project at St. Paul. On June 29, 1981, staff from the Division of Waters met with the project manager, Mr. Bjorkquist, to discuss the matter.

The Minnesota Department of Natural Resources continues to support programs and projects that will reduce the potential for loss of life and the damages caused by flooding, provided that these programs and projects can be implemented in an economically, environmentally and socially acceptable manner, and are consistent with state regulations. The proposed improvements at St. Paul seem to meet these criteria and are generally consistent with Minn. Reg. NR 85(e)(2), which in part reads as follows:

> (2) The minimum height and structural design of any dikes, levees, floodwalls or similar structural works in place, or proposed to be placed in the flood plain shall be based on the flood profile of the regional flood confined between the structures subject to the following:
>
> (aa) For urban areas the minimum authorized height and design of proposed structural works shall be at least three feet above the elevation of the regional flood, as confined by the structures, or shall be at the elevation of the standard project flood, whichever provides the greater protection from flooding.

The term "Standard Project Flood" is defined in Minn. Reg. NR 85 (c) as:

> "Standard Project Flood" means the flood that may be expected from the most severe combination of meteorological and hydrological conditions that is considered reasonably characteristic of the geographical area in which the drainage basin is located, <u>excluding extremely rare combinations</u> (emphasis added). Such floods are intended as practicable expressions of the degree of protection that should be sought in the design of flood control works, the failure of which might be disastrous.

This does not necessarily imply that for purposes of the state regulations, a standard project flood at the subject site amounts to a peak flowrate of 260,000 cubic feet per second, as apparently determined by the Corps of Engineers for federal purposes. Nevertheless, it does not appear that the existing protective works, which were constructed prior to promulgation of the aforementioned regulations,would meet the current state standards relative to the standard project flood. Our Division of Waters will, of course, be working with your personnel during the planning process in determination of the standard project flood for purposes of the state regulations and, hence, the level of protection for St. Paul thereby required.

This Department's staff has some concern that the proposed project will provide additional protection to an area that already has a level of protection sufficient to encourage substantial new development in recent years, while other areas of Minnesota experiencing extensive damages and potential for loss of life have no protection at all and are essentially precluded from new flood plain development. In this period of limited budgets at both the state and federal levels, it seems that governmental emphasis must be on implementing programs and projects for unprotected areas, particularly if, as the Corps asserts, the cost-sharing formula proposed by President Carter in 1978 is determined to be applicable to the project.

You are of course aware that no action has been taken by Congress on this cost-sharing proposal. Until some action is taken by Congress, it is felt that the traditional cost-sharing rules should continue to apply.

Thank you again for the opportunity to comment on this project. If you have additional questions about this project, please contact Mr. Joseph Gibson of my staff at (612) 296-0438.

Sincerely,

Joseph N. Alexander
Commissioner

cc: George Latimer, Mayor of St. Paul
Gary Botzek, Governor's Office
Tom Kalitowski, Water Planning Board
Larry Seymour, Div. of Waters Director

amhoist AMERICAN HOIST & DERRICK COMPANY 63 SOUTH ROBERT STREET, ST. PAUL, MN 55107

August 5, 1981

Colonel William Badger
CORPS OF ENGINEERS
1135 U.S. Post Office
and Custom House
St Paul, MN 55101

REFERENCE: St Paul Flood Control Project -
Announcement of July 24, 1981

Dear Colonel Badger:

In response to your announcement of July 24, 1981 and the Feasibility Evaluation Report of the St Paul Flood Project of December 1980, American Hoist & Derrick Company agrees that the flood wall should be increased.

The flood of 1969 and especially 1965 caused severe concern that this facility, which serves as our world headquarters and employs approximatley 1,850 people with a large investment in real as well as personal property, would be in great danger. During those times, complete shutdown was a near reality.

We have discussed the feasibility of wall height increases with the Corps before and have serious concerns that we wish to make you aware of. The increasing of that wall landward of the river would cause American Hoist extreme problems.

Our operation involves heavy equipment manufacturing and the flow of our finished product, as well as new developments, involves movement from final assembly to the north and parallel with the flood wall to our test yard (photo attached). Clearance out of our building and along the flood wall is at the minimum at present. With increased height of the wall as proposed, the distance between our buildings and the flood wall would be shortened and would pose impossible restrictions. Increasing of the flood wall along our

Cable Address/Derrick: W.U. TELEX: General 29/7028: Parts 29/7062: Sales 29/7432: Telephone 612/293/4567:

final assembly area would have to occur on the water side of the Mississippi and, possibly, with the usage of some type of removable flood gate. This problem needs to be reviewed in future studies with our manufacturing personnel.

We will cooperate in any way possible and feel that this is a viable project to us as well as to all others in the Riverview Industrial Park.

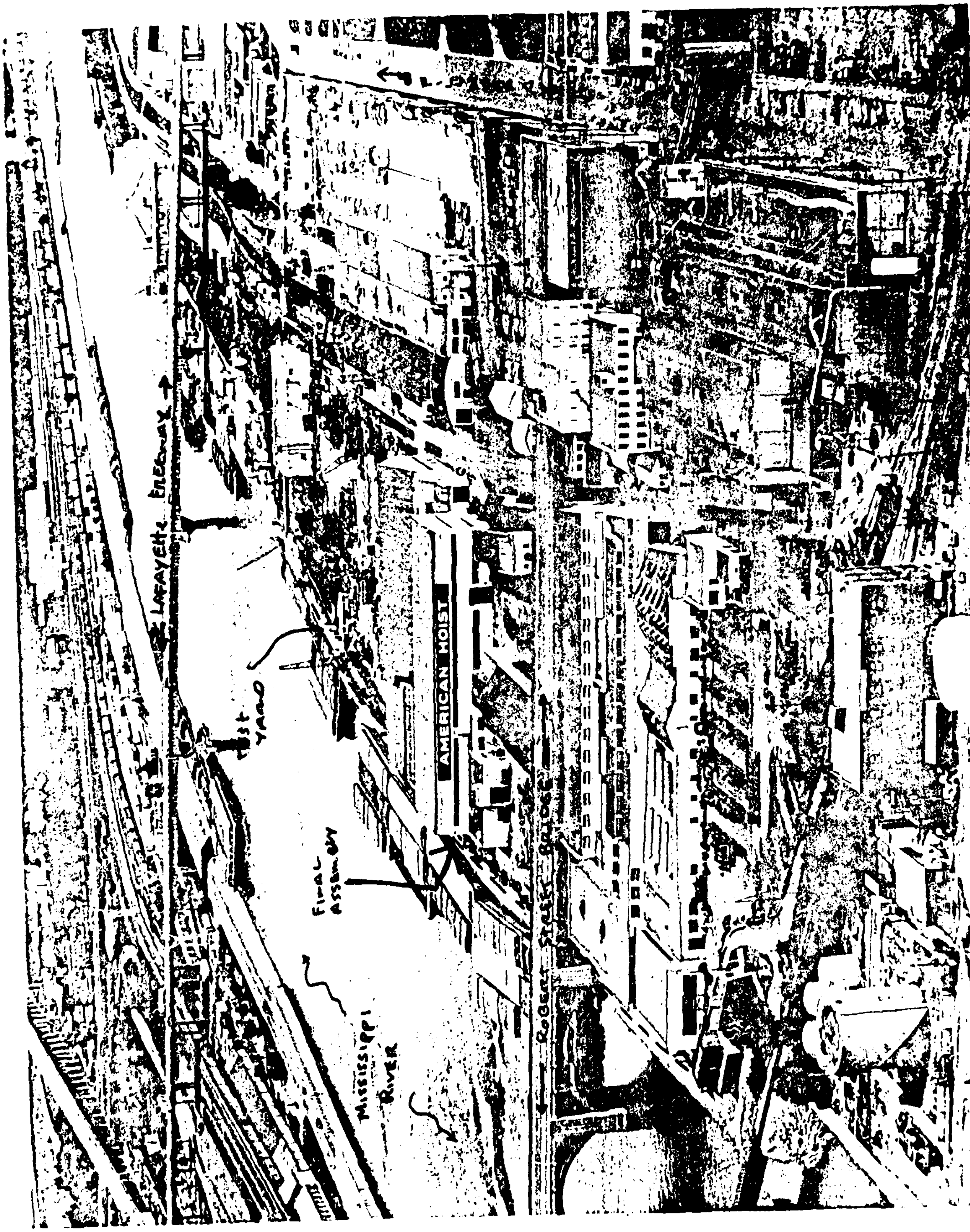
Sincerely,

Kurt Williamson

(Telephone: 293-4215)

/jg

cc: F Bremer - Amhoist
D Nordstrand - Amhoist
G Kraut - St Paul Port Authority
A Bjorkquist - Corps of Engineers



Downtown St Paul

CITY OF SAINT PAUL
OFFICE OF THE MAYOR

347 CITY HALL
SAINT PAUL, MINNESOTA 55102
(612) 298-4323

GEORGE LATIMER
MAYOR

September 14, 1981

Col. William A. Badger, District Engineer
U.S. Army Corps of Engineers
1135 U.S. Post Office Building
St. Paul, Minnesota 55102

Dear Col. Badger:

Over the past two years, the City of St. Paul has monitored the Corps of Engineer's study and proposal to upgrade the flood protection facilities at Riverview Industrial Park in St. Paul. On three previous occasions I have expressed the city's appreciation of and interest in the study, pointing out the importance of Riverview to the city, and recommending various issues to be addressed, and items to be considered. I'm grateful for the opportunity to participate with the Corps in working out the intricacies of this project. This is a most important project to St. Paul.

City staff has evaluated the latest proposal to raise the levees and floodwall by 4 feet and to improve drainage and seepage in the vicinity of the levee. We have concurred that this is a reasonable solution among the alternatives presented, and we support its implementation. Consequently, the City of St. Paul is willing to sponsor the project through its review processes.

Your staff has been most helpful in outlining the implications of this project to the city. We have a thorough understanding of the estimated costs of the project and the city's responsibilities under Federal Law in contributing to implementation of it. To the best of our abilities, the city is willing to meet the obligations of local government in these matters. Our abilities to do so are largely determined by costs. In a period of general government cutbacks in service to citizens, it is understandably difficult to expect that local government in general and St. Paul in particular can devote substantial portions of a yearly budget to an individual project such as this. Consequently, we will be seeking to minimize the city's costs, and would prefer that the Corps utilize the "traditional" policy of cost sharing, as established by Congress. Our analysis of President Carter's cost allocation policy for this project indicates that St. Paul's expected contribution would be excessive under that policy.

My purposes in this letter is to indicate the St. Paul's intent to follow through on the implementation procedures for the project. We understand that the Corps will be seeking a firm, binding commitment of participation from the city only after Congressional authorization of the project. Until then, the city is not obligated to participate

or contribute. In the interim, city staff will continue to work with the Corps and affected organizations and companies to refine the proposal. Prior to formally committing to participation by contract, we will evaluate the refined proposal to insure that local objectives continue to be addressed.

Thank you again for the opportunity to present our views. The City of St. Paul is very anxious that this project be implemented. We will continue to to what we can to see that this occurs.

Sincerely,

George Latimer

George Latimer
Mayor

cc: Congressman Vento
Governor Quie
Robert Sprafka
Jim Bellus
Tom Kelley
Ralph Brown, WSCO
Greg Blees

MINNESOTA HISTORICAL SOCIETY
FOUNDED IN 1849
690 Cedar Street, St. Paul, Minnesota 55101 • (612) 296-6126

28 September 1981

Mr. Robert F. Post
Chief, Environmental Resources Branch
Engineering Division
Department of the Army
Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, MN 55101

Dear Mr. Post:

RE: St. Paul Flood Control Project
On the Mississippi River
Effects of the Modification
On the Minnesota Boat Club
Ramsey County

MHS Referral File Number: N 552

Thank you for the opportunity to review and comment on the above project. It has been reviewed pursuant to responsibilities given the State Historic Preservation Officer by the National Historic Preservation Act of 1966 and the Procedures of the National Advisory Council on Historic Preservation (36CFR800).

It is apparent from your letter and conversations with your staff that much time and attention was given in assessing the possible effect of the recommended 4-foot raise of the current flood barrier on the Minnesota Boat Club, a property that has been determined eligible for inclusion on the National Register.

Our analysis of the data presented on the elevation of the building and the projected flood surface elevations results in a concurrence with your opinion that the work will have no effect on the Minnesota Boat Club. It appears that the potential effect on the structure by the four foot increase in the flood barrier would be caused by a flood that would have a water surface level well beyond the 1965 flood of record, and would have an effect that would be of little difference if the flood wall was not raised. Therefore, it is our opinion that the difference in the effect (between a 4-foot barrier and the existing barrier) is too remote and minor to be of any consequence. We would suggest that assistance be given to Doug Holmberg, President of the Minnesota Boat Club, in providing for a deflector that will divert debris away from the structure in the event of a flood of magnitude that would overtop the barrier.

If you have further questions or comments, please do not hesitate to contact Ms. Susan Hedin, Environmental Assessment Officer, State Historic Preservation Office, 240 Summit Avenue, St. Paul, MN 55102, 296-0103.

Again, thank you for your time and attention in explaining the project modifications and how the Boat Club could be potentially affected by the various flood elevations.

Sincerely,

Dennis A. Gimmestad

for Russell W. Fridley
State Historic Preservation Officer

RWF/sl

ALBERT H. QUIE
GOVERNOR

STATE OF MINNESOTA

OFFICE OF THE GOVERNOR

ST. PAUL 55155

October 13, 1981

Colonel William W. Badger
St. Paul District Engineer
Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Badger:

Thank you for your letter concerning flood control on the Mississippi River.

The State of Minnesota continues to support flood control projects that reduce the loss of life and the damages caused by severe flood events. The proposed improvements to the flood control project at St. Paul will provide additional protection against loss of life and property damage in the Riverview Industrial Park area of St. Paul. Of the alternatives investigated, the proposed four-foot increase in the height of the floodwall seems to be the most economically and environmentally feasible alternative. For these reasons, I support efforts to seek congressional authorization for the proposed project.

I continue to question the applicability of the cost-sharing formula proposed by President Carter in 1978 since the Congress has not taken any action to reaffirm this policy. Several cost-sharing and cost-recovery proposals are currently under consideration by the Administration and the Congress, but no decision has yet been made about the amount and the source of non-federal cost-sharing for federal projects. Once a final decision has been made about non-federal cost sharing, the State of Minnesota will reexamine its position on the project.

Thank you for the opportunity to provide these comments. If you need further assistance on this matter, please contact Mr. Larry Seymour, Director of the Division of Waters of the Department of Natural Resources, at 296-4810.

Sincerely yours,

Al Quie

ALBERT H. QUIE
GOVERNOR

cc: Senator David Durenburger
Senator Rudy Boschwitz
Representative Bruce Vento
Mayor George Latimer
Larry Seymour

PERTINENT CORRESPONDENCE FROM PRIOR STAGES

Letter from City of St. Paul Public Works, 20 November 1979.

Letter from U.S. Department of the Interior, Fish and Wildlife Service, 7 September 1979.

Letter from U.S. Department of the Interior, Fish and Wildlife Service, 30 April 1979.

Letter from Minnesota Department of Natural Resources, 19 April 1979.

Letter from Department of Housing and Urban Development, 16 April 1979.

Letter from Department of the Interior, Fish and Wildlife Service, 6 April 1979.

Letter from Environmental Protection Agency, 22 March 1979.

Letter from Metropolitan Council, 12 March 1979.

Letter from Department of Transportation, Federal Aviation Administration, 7 March 1979.

Letter from Mayor of St. Paul, 1 March 1979.

Letter from Minnesota Department of Health, 22 February 1979.

Letter from State of Minnesota, Department of Agriculture, 15 February 1979.

Letter from Department of Transportation, Federal Aviation Administration, 20 September 1978.

Letter from Minnesota Historical Society, 5 June 1978.

GEORGE LATIMER
MAYOR

CITY OF SAINT PAUL
DEPARTMENT OF PUBLIC WORKS

DONALD E. NYGAARD, DIRECTOR
234 City Hall, Saint Paul, Minnesota 55102
612-298-4241

November 20, 1979

Mr. Ray Sanford
St. Paul District
U.S. Corps of Army Engineers
1135 U.S. Post Office
St. Paul, Minnesota 55101

Dear Mr. Sanford:

At your request, personnel in the Department of Public Works have investigated the possibility of raising the maximum inlet pool elevation at the Moses Street Pump Station. This letter is intended to summarize the investigation and to confirm conversations between yourself and personnel in the Sewer Design Bureau.

During your meeting with Roger Puchreiter and Michael Knutson on November 15, 1979, you expressed interest in receiving approval from this bureau to operate the Moses Street Pump Station at two to four feet higher than the present normal operating level during severe emergency flood situations. Because there was some ambiguity in what the normal pool operating elevation was and on which datum this elevation was based, we requested that additional information be supplied.

During your telephone conversation with Michael Knutson later on November 16, you indicated that the pool elevation at Moses Street Pump Station was based on the 1912 Datum of 694.58' M.S.L. Using that Datum, you established the bottom pool elevation to be 684.40' M.S.L., and the maximum emergency pool operating level of 694.40' M.S.L.

A maximum emergency pool operating level of 694.40' M.S.L. will not cause backups into basements attached to the St. Paul combined sewer system and is, therefore, acceptable. If it is determined that a pool elevation operating level significantly greater than this is required, it could lead to backups. This could be alleviated by the construction of a separate sanitary sewer for approximately $15,000 to serve this area.

During your November 16 telephone conversation with Mr. Knutson, you indicated that the maximum pool operating level at the Custer Street Pump Station would be 694.20' M.S.L. This should not result in combined sewer backups and is acceptable as well.

Sincerely,

Roy E. Bredahl Jr.

Roy E. Bredahl, Jr.
Sewer Engineer

REB:MK:mf

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

IN REPLY REFER TO:
AFA-SE

SEP 7 1979

Colonel William D. Badger
District Engineer
U. S. Army Engineer District, St. Paul
1135 U. S. Post Office & Custom House
St. Paul, MN 55101

Dear Colonel Badger:

Reference your letter dated August 7, 1979 (NCSED-ER). I have reviewed the biological assessments conducted on 2 of 24 St. Paul District Corps projects for which we supplied endangered species lists on April 30, 1979. The following comments will address each project individually.

1. Wild Rice-Felton Ditch, Norman and Clay Counties, Minnesota.

   I am concerned about the potential depredation of approximately 2,300 acres of native prairie within the project area which has been proposed as critical habitat for the Dakota skipper butterfly (Hesperia dacotae). Although the species has not yet been officially listed as threatened, the likelihood of listing within the next year is good.

   Therefore, the alternative to constructing levees within Section 13 of the project area (as outlined in 4.05 of the biological assessment) should be strongly considered. Please send us the results of the evaluation of the topographic data presently being collected relative to this alternative.

   I concur with your views on the lack of Arctic peregrine falcon (Falco peregrinus tundrius) breeding habitat and it is my biological opinion that the project, as currently planned, will not jeopardize the continued existence of this species.

2. St. Paul Flood Control Project, Ramsey County, Minnesota.

   Although the Arctic and American peregrine falcons (Falco peregrinus tundrius) and (Falco peregrinus anatum) occasionally migrate through the Twin Cities area and historic and potential breeding habitat exists along the upper Mississippi River, I concur that no significant adverse impacts should result from the proposed project action in this highly urbanized and industrial area.

   I have reviewed Dr. Samuel Fuller's 1978 Final Report to Corps of Engineers on "Fresh Water Mussels (Mollusca: Bivalvia: Unionidae)

of the Upper Mississippi River (No. 78-33)" and note that no live mussels were taken in 30,000 square feet of sampling (6 brail runs) within the project area. Your description of the stream bed and water quality also indicates it is unsuitable habitat for the endangered Higgin's eye pearly mussel (Lampsilis higginsi), therefore, it is my biological opinion that the project, as currently proposed, is not likely to jeopardize the continued existence of Federally listed species.

This letter provides comment only on the endangered species aspect of the project. Comments on other aspects of the project under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et. seq.) may be sent under separate cover.

Sincerely yours,

Charles A. Hughlett

Charles A. Hughlett
Acting Regional Director

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

IN REPLY REFER TO:
AFA-SE

APR 30 1979

Colonel Forrest T. Gay III
District Engineer
U. S. Army Engineer District
St. Paul
1135 U. S. Post Office and
Custom House
St. Paul, MN 55101

Attn: Roger G. Fast
Chief, Engineering Division

Dear Colonel Gay:

This is in response to your letter of April 18, 1979, NCSED-ER, in which you requested endangered species information for 24 Corps projects in Minnesota, Wisconsin and Michigan.

Based upon information currently available, the following threatened (T), endangered (E), or proposed (P) species may be found within the project area:

Section 107 - Small Boat Harbors

Grand Portage, Minnesota — Cook County
- Bald Eagle (T) (*Haliaeetus leucocephalus*)
- Gray Wolf (T) (*Canis lupus*)
- American Peregrine Falcon (E) (*Falco peregrinus anatum*)
- Arctic Peregrine Falcon (E) (*Falco peregrinus tundrius*)

In addition, the project area falls within the critical habitat designated for the Gray Wolf.

Warroad, Minnesota — Roseau County
- Gray Wolf (T) (*Canis lupus*)
- Arctic Peregrine Falcon (E) (*Falco peregrinus tundrius*)
- Bald Eagle (T) (*Haliaeetus leucocephalus*)

Lake City, Minnesota — Wabasha County
- Bald Eagle (T) (*Haliaeetus leucocephalus*)
- American Peregrine Falcon (E) (*Falco peregrinus anatum*)
- Arctic Peregrine Falcon (E) (*Falco peregrinus tundrius*)
- Higgin's Eye Pearly Mussel (E) (*Lampsilis higginsi*)
- Pennsylvania Smartweed (P) (*Polygonum pensylvanicum*)

Ashland, Wisconsin   Ashland County
Bald Eagle (T)   (*Haliaeetus leucocephalus*)
American Peregrine Falcon (E)   (*Falco peregrinus anatum*)
Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)

Washburn, Wisconsin   Bayfield County
Bald Eagle (T)   (*Haliaeetus leucocephalus*)
American Peregrine Falcon (E)   (*Falco peregrinus anatum*)
Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)

Section 103 - Beach Erosion

Ashland, Wisconsin   Ashland County
Same as above.

Two Harbors, Minnesota   Lake County
Gray Wolf (T)   (*Canis lupus*)
Bald Eagle (T)   (*Haliaeetus leucocephalus*)
American Peregrine Falcon (E)   (*Falco peregrinus anatum*)
Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)

Section 205 - Small Flood Control Projects

Warren, Minnesota (Snake River)   Polk, Marshall, Pennington Counties
Gray Wolf (T)   (*Canis lupus*)
Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)

Section 14 - Emergency Bank Stabilization

Mahnomen, Minnesota   Mahnomen County
Gray Wolf (T)   (*Canis lupus*)
Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)

Section 111 - Mitigation for Shore Damage

Big Bay, Michigan   Marquette County
Bald Eagle (T)   (*Haliaeetus leucocephalus*)
American Peregrine Falcon (E)   (*Falco peregrinus anatum*)
Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)

Grand Traverse Bay Harbor, Michigan   Houghton County
Bald Eagle (T)   (Haliaeetus leucocephalus)
American Peregrine Falcon (E)   (*Falco peregrinus anatum*)
Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)

Presque Isle Harbor, Marquette, Michigan   Marquette County
Bald Eagle (T)   (*Haliaeetus leucocephalus*)
American Peregrine Falcon (E)   (*Falco peregrinus anatum*)
Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)

Advance Engineering and Design

Beaver Bay, Minnesota   Lake County
- Gray Wolf (T)   (*Canis lupus*)
- American Peregrine Falcon (E)   (*Falco peregrinus anatum*)
- Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)
- Bald Eagle (T)   (*Haliaeetus leucocephalus*)

Lutsen, Minnesota   Cook County
- Gray Wolf (T)   (*Canis lupus*)
- American Peregrine Falcon (E)   (*Falco peregrinus anatum*)
- Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)
- Bald Eagle (T)   (*Haliaeetus leucocephalus*)

In addition, the project area falls within the critical habitat designated for the Gray Wolf.

Rochester, Minnesota   Olmsted County
- American Peregrine Falcon (E)   (*Falco peregrinus anatum*)
- Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)

Twin Valley Lake, Minnesota   Norman County
- Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)

Construction

Wild Rice - Felton Ditch, Minnesota   Clay & Norman Counties
- Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)
- Dakota Skipper Butterfly (P)   (*Hesperia dacotae*)

Big Stone - Whetstone, Minnesota   Big Stone Coonty
- Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)

Rushford, Minnesota   Fillmore County
- American Peregrine Falcon (E)   (*Falco peregrinus anatum*)
- Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)
- Pennsylvania Smartweed (P)   (*Polygonum pensylvanicum*)

Roseau River, Minnesota   Roseau & Kittson Counties
- Gray Wolf (T)   (*Canis lupus*)
- Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)
- Bald Eagle (T)   (*Haliaeetus leucocephalus*)

Two Harbors, Minnesota   Lake County
- Gray Wolf (T)   (*Canis lupus*)
- American Peregrine Falcon (E)   (*Falco peregrinus anatum*)
- Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)
- Bald Eagle (T)   (*Haliaeetus leucocephalus*)

General Investigations

Wisconsin River, Portage, Wisconsin   Columbia County
- American Peregrine Falcon (E)   (*Falco peregrinus anatum*)
- Arctic Peregrine Falcon (E)   (*Falco peregrinus tundrius*)
- Kirtland's Warbler (E)   (*Dendroica kirtlandii*)

Redwood River, Marshall, Minnesota   Lyon County

Arctic Peregrine Falcon (E)   (Falco peregrinus tundrius)
Pennsylvania Smartweed (P)   (Polygonum pensylvanicum)

St. Paul Flood Control   Ramsey County

American Peregrine Falcon (E)   (Falco peregrinus anatum)
Arctic Peregrine Falcon (E)   (Falco peregrinus tundrius)
Higgin's Eye Pearly Mussel (E)   (Lampsilis higginsi)

In accordance with the Endangered Species Act of 1973, as amended, the Federal Agency responsible for actions authorized, fund r carried out in the furtherance of the projects is required to cond ct a biological assessment for the purpose of identifying endangered or threatened species likely to be affected by the action. If the biological assessment indicates the presence of such species, the formal consultation process should be initiated. This should be done by writing to the Regional Director, U. S. Fish and Wildlife Service, Federal Building, Fort Snelling, Twin Cities, Minnesota 55111.

After receiving the species information, the biological assessment is to be completed within 180 days, and before contracts are entered into or construction begun.

The biological assessment should include the following information:

1. Identification of the species and any legally determined Critical Habitats or any habitat considered to be essential to the species present in the area influenced by the construction.

2. A description of the kinds and time period of the construction.

3. An assessment of the potential impacts of the project on the species or Critical Habitat.

4. A discussion of efforts taken to eliminate any adverse effects or impact on the species or habitats.

If there are any questions or you require further information please contact the Region 3 Endangered Species Office at 612-725-3596.

Sincerely yours,

Charles A. Hughlett

Charles A. Hughlett
Acting Regional Director

STATE OF
MINNESOTA
DEPARTMENT OF NATURAL RESOURCES
444 Lafayette Road, Space Center Bldg., St. Paul, MN 55101

PHONE: 296-4810 File No.

April 19, 1979

Forrest T. Gay, III
Colonel, Corps of Engineers
District Engineer, St. Paul
1135 U.S. Post Office & Custom House
St. Paul, MN 55101

Dear Colonel Gay:

Thank you for your letter of February 9, 1979, furnishing a copy of your preliminary feasibility report, Mississippi River at St. Paul, Minnesota, Reevaluation of St. Paul Flood Control Project. My staff has reviewed the document and wishes to offer the following comments:

Page 15, Transportation Section. Bus service is also provided by private companies other than the Metropolitan Transit Commission and we feel your statement should be amended to reflect this.

Page 28, No Action (Alternative 1). This alternative should include a discussion on the availability of flood insurance. Coverage through the National Flood Insurance Program is not mandatory, since the area is designated as Zone B because of the existing project. Insurance rates are not subsidized and should reflect the true hazard at the site. Since this office has received calls from actuaries concerning the flood hazard, we assume a number of firms are insured against flood damage by private insurance companies.

Also, the second paragraph on page 28 indicates that future development in the protected area "...is not restricted by either State law or local ordinances." The area is mapped as 500 year flood plain on the city's flood insurance rate map, which places it in the "Secondary Flood Hazard Area" category of the State Building Codes flood-proofing standards. Since the city enforces the code, there are some special requirements for future development in the area, which are related to flooding hazards.

Page 29, Item d. Our regional staff indicates that the reconstruction of the Childs-Warner Road intersection is now complete. Your report should be updated to reflect this when it is re-drafted.

Page 32, Flood Insurance and Floodplain Regulation (Alternative 4). The narrative for this alternative is unclear. In the table on page 41, alternative 4 includes regulation of the remaining land behind the project

and mandatory flood insurance. If this is the intent of alternative 4, it should be clearly stated in the narrative on page 32. It should be pointed out that neither land use regulations nor flood insurance are required by state or federal laws. Any such program would have to be initiated by the City of St. Paul.

Also, my staff would be very interested in seeing the calculations and back-up data used to develop the positive benefit/cost ratio for this alternative. It has been our experience that past reports on projects similar to this, have shown negative ratios and we are curious as to the methodology employed in this particular case which resulted in the positive ratio.

Page 33, last paragraph. We feel this paragraph should acknowledge low flow augmentation as a primary purpose for the headwaters reservoirs construction.

Page 39, second paragraph, fourth sentence. This sentence appears to be judgemental in stating that "Flood proofing...is not acceptable to the public.", without some substantiation. We agree that this alternative is probably not viable in this particular situation, but it may be in other cases, especially if a "public agency" pays for it.

We trust these comments will be useful. Thank you for allowing an opportunity to provide input to your planning process.

Sincerely,

DIVISION OF WATERS

Larry Seymour
Director

LS/ef:ls

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
CHICAGO REGIONAL OFFICE
300 SOUTH WACKER DRIVE
CHICAGO, ILLINOIS 60606

REGION V

APR 16 1979

IN REPLY REFER TO:
5C

Forrest T. Gay III
Colonel, Corps of Engineers
St. Paul District, Corps of Engineers
1135 U. S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Gay:

This is in response to your letter dated February 9, 1979 wherein you request our comment on the preliminary feasibility report, Mississippi River at St. Paul, Minnesota, Reevaluation of St. Paul Flood Control Project. Through our review we note the following:

1. On page 32, flood insurance and flood plain regulations are listed as alternatives (alternative 4 in report) to allowing flood plain development. It appears doubtful that flood plain regulations could legally be imposed, according to existing National Flood Insurance Program guidelines, in areas adequately protected from the 100 year flooding event. Thus, alternative 4 may not be workable, as the area mentioned is protected from a 100 year flood.

2. Also on page 32, reference is made to the fact that no national economic development benefits can be attributed to a flood insurance program. We feel that a qualification of this statement is in order because of the dual purpose associated with the National Flood Insurance Program (NFIP). It is true that flood insurance alone does not prevent flood damages and only reimburses property owners for losses sustained from flood damages. However, the other objective of the NFIP is to motivate communities to enforce sound flood plain management measures. When flood plain management is coupled with the provision for flood insurance availability, it is likely that the NFIP, in the long range, will be of national economic benefit. This is simply due to the dollars not paid out in disaster relief and assistance.

As of April 1, 1979 the Flood Insurance Administration has left this Department to become part of the Federal Emergency Management Agency. To obtain the viewpoint of that Agency you may direct a copy of future proposals to:

Frank Finch, Director
Flood Insurance Administration
Federal Emergency Management Agency
1 North Dearborn, Room 540
Chicago, Illinois 60602

We appreciate the opportunity to comment on this project.

Sincerely,

Ron Gatton
Regional Administrator

United States Department of the Interior
FISH AND WILDLIFE SERVICE
St. Paul Field Office, Ecological Services
538 Federal Building and U.S. Court House
316 North Robert Street
St. Paul, Minnesota 55101

IN REPLY REFER TO:

April 6, 1979

Colonel Forrest T. Gay, III
Dist. Engineer, St. Paul Dist.
U.S. Army Corps of Engineers
1135 U.S. Post Office
St. Paul, MN 55101

Dear Colonel Gay:

This provides our comments on the Preliminary Feasibility Report for the St. Paul Flood Control Project.

From the point of view of the least damaging alternatives to fish and wildlife resources, we agree with the conclusion that alternatives #1 (no action), 4 (nonstructural), and 7 (barrier expansion) are the most desirable for inclusion in the final feasibility study. Alternative #5 (channel modification) is especially undesirable with respect to probable adverse impacts to Mississippi River fish and wildlife resources. Likewise, alternative #6 (reservior development) would be potentially destructive to valuable natural resources on the Mississippi and Minnesota Rivers.

These comments have been prepared under the authority of and in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and are consistent with the intent of the National Environmental Policy Act of 1969.

Sincerely,

Richard F. Berry

Richard F. Berry
Field Office Supervisor

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION V
230 SOUTH DEARBORN ST.
CHICAGO, ILLINOIS 60604

MAR 22 1979

Colonel Forrest T. Gay, III
District Engineer
U.S. Army Engineer District, St. Paul
1135 U.S. Post Office and Custom Houst
St. Paul, Minnesota 55101

Dear Colonel Gay:

Your letter of February 9, 1979, provided us with the preliminary feasibility report for additional flood control, Mississippi River at St. Paul, Minnesota. We have reviewed this feasibility report to determine whether or not we had any concerns or objections based upon the environmental impacts of the alternative actions.

Since the work is to provide additional protection in St. Paul adjacent to the Mississippi River, the environmental impacts should be minimal. The three alternatives to be studied further appear to be reasonable and we do not have any objections to the continued study of these flood control improvements.

We appreciate your providing us this feasibility report. If you or your staff has any questions in regard to our review, please contact Mr. William Franz at 312/353-2307.

Sincerely yours,

Joseph J. Soird

Barbara J. Taylor, Chief
Environmental Impact Review Staff
Office of Federal Activities

Metropolitan Council
300 Metro Square Building
Seventh Street and Robert Street
Saint Paul, Minnesota 55101

Telephone (612) 291-6453

Office of the Chairman

March 12, 1979

Colonel Forrest T. Gay, III
District Engineer, Corps of Engineers
St. Paul District
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

RE: Preliminary Feasibility Report
Mississippi River at St. Paul, Mn.
Reevaluation of St. Paul Flood Control Project
Metropolitan Council Referral File No. 4488-2

Dear Colonel Gay:

At its meeting March 8, 1979, the Metropolitan Council considered the above report. The Metropolitan Council would like to recommend that three items be addressed during the detailed evaluation of alternatives. First, the analysis of alternatives should include an evaluation of the impacts on and consistency of any project with the St. Paul Critical Area River Corridor Plan, particularly the impact on barge fleeting along the river and on existing and proposed riverfront land uses, such as barge terminals, public open space, and general public access to the river. Secondly, the analysis should address the potential impacts of any project on Harriet Island Regional Park and on any other aspects of regional open space that might be impacted. Finally, the Council would like the Corps to address how this project fits into the overall flood protection of the St. Paul industrial corridor. This concern is raised because of discussions in the preliminary feasibility report on flooding problems outside of the project area.

Sincerely,

METROPOLITAN COUNCIL

Charles R. Weaver

Charles R. Weaver
Chairman

CRW:jg
cc: George Latimer, Mayor, City of St. Paul
Gary Oberts, Metropolitan Council Staff

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Airports District Office
6301 - 34th Avenue South
Minneapolis, MN 55450

March 7, 1979

Colonel Forrest T. Gay, III
District Engineer
Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Attention: NCSED - PB

Dear Colonel Gay:

We have reviewed the preliminary feasibility report, Mississippi River at St. Paul, Minnesota, Re-evaluation of St. Paul Flood Control Project, and have no comment on the report.

We wish to thank you for the opportunity of this review and request that we be kept informed as the study progresses.

Sincerely,

Donald R Stockdale

DONALD R. STOCKDALE
State Program Officer

CITY OF SAINT PAUL
OFFICE OF THE MAYOR

347 CITY HALL
SAINT PAUL, MINNESOTA 55102
(612) 298-4323

GEORGE LATIMER
MAYOR

March 1, 1979

Col. Forrest T. Gay, III
District Engineer
Corps of Engineers
1135 U.S. Post Office
St. Paul, Minnesota 55101

RE: Preliminary Feasibility Report; Reevaluation of St. Paul Flood Control Project; NCSED-PB
Metropolitan Council File #4488-2

Dear Col. Gay:

The City of St. Paul has carefully reviewed the September 1978 draft of the above report and appreciates the opportunity to comment on it. We are very anxious that an appropriate means of flood control is instituted in the area you are studying. As I pointed out in my June 1977 letter to you on the matter, the City of St. Paul and various private companies have an enormous investment in the Riverview Industrial Park. It is in the public's best interest to insure that Riverview is adequately protected against flood damage.

Our staff believes that your second stage report is quite well done. The assumptions made about future activities in Riverview are essentially correct, although some specific recommendations you cite from our Critical Area planning efforts are dated. For your further information, the St. Paul Mississippi River Corridor Plan was approved by the City Council in December 1978 and is currently being reviewed by the Metropolitan Council. It states that "...federal agencies will be encouraged to improve existing facilities to accommodate projected demands and extend their useful life." This is a clear reference to the Corps' anticipated project improvements in our city.

We find little fault with your identification and evaluation of alternative flood control means. The costs and benefits associated with various social, economic and environmental impacts are comprehensive and carefully thought out. St. Paul agrees most emphatically that alternatives suggesting removal of existing structures from flood hazard areas and some alternatives of individually protecting structures are economically unacceptable, despite their effectiveness in flood protection. However, we are not ready to rule out all methods of individual protection, and hope that the Corps will assist businesses in determining how appropriate this alternative would be on a case-by-case basis.

We also suggest an evaluation of one other alternative, namely Upstream Floodplain Regulation. The city is anxious to participate in the further study of floodplain regulation in Riverview, as is recommended. However,

it appears that upstream floodplain development could have significant impact on flood levels, as upstream reservoirs do. Implementation of such a regulation alternative might spread its costs throughout the region and make it feasible enough for further study.

Finally, we hope that the ultimate solution to the problem is a combination of alternatives rather than a single one. We agree that the structural alternatives recommended for further evaluation appear to have the best cost benefit ratio, but see merit in supplementing the best structural alternative with acceptable non-structural alternatives. This would create badly needed overall policy directed at minimizing flood damage.

In addition, please note that any structural improvements to the floodwall or levee would require a Floodplain Conditional Use Permit as stipulated in the St. Paul Zoning Ordinance.

Thank you for the opportunity to comment. I am looking forward to continued discussions of this most important issue. Please let me know if I can provide additional information or assistance.

Sincerely,

George Latimer
Mayor

cc: Gary Stout
James Bellus
Jim O'Leary
Robert Sprafka
John Rutford, Metro Council

minnesota department of health
717 s.e. delaware st. minneapolis 55440
612 296-5221

February 22, 1979

Mr. Ray Sandford
Department of the Army
St. Paul District, Corps of Engineers
1135 U. S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Mr. Sandford:

Thank you for the draft of "Preliminary Feasibility Report Mississippi River At St. Paul, Minnesota, Reevaluation Of St. Paul Flood Control Project."

The Minnesota Department of Health has concerns about water wells in flood protected areas, because of the possibility of contamination to the ground water through flooded water wells. The Department is of the opinion that flood protection of water wells in these areas should be given a high priority. Such protection would include the sealing of all abandoned wells, and the flood protection of active wells.

We appreciate the opportunity to have reviewed the draft of your report, and ask that the protection and abandonment of water wells be given your consideration in flood areas under study.

Yours very truly,

Edwin H. Ross, Supervisor
Ground Water Quality Control Unit

AD-A116 378 CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT F/G 13/2
FEASIBILITY REPORT. MISSISSIPPI RIVER AT SAINT PAUL, MINNESOTA.--ETC(U)
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LAND OF QUALITY FOODS

STATE OF MINNESOTA

DEPARTMENT OF AGRICULTURE
STATE OFFICE BUILDING
SAINT PAUL, MINN. 55155
Telephone: (612) 296-2856

OFFICE OF THE COMMISSIONER

February 15, 1979

Colonel Forrest T. Gay III
District Engineer
U. S. Army Corps of Engineers, St. Paul District
1135 U. S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Gay:

Thank you for your transmittal of the preliminary feasibility report, Reevaluation of the St. Paul Flood Control Project, Mississippi River at St. Paul, Minnesota.

The Minnesota Department of Agriculture is concerned with the adequacy of existing and planned flood control for several reasons:

1. Effective flood control can prevent or minimize the economic and social impact of anticipated natural disaster.

2. Agriculture, Minnesota's biggest and most important industry, has a significant dependence upon and an increasing economic investment in many of the food and fiber supply, service, marketing, processing, and transportation industries that are situated within the St. Paul Flood Control Project. Flood damage to and disruption of these industries could have a damaging secondary impact upon our agricultural economy.

3. The headquarter offices and laboratories of the Minnesota Department of Agriculture are scheduled to be moved into the state-leased quarters of a new building to be erected this year within the Riverview Industrial Area.

We offer our interest and cooperation in the continuing study by the St. Paul District Corps of Engineers and in the final feasibility report scheduled for completion early in 1981.

Sincerely,

MINNESOTA DEPARTMENT OF AGRICULTURE

Mark W. Seetin
Commissioner

MWS:jyp
cc: Deputy Commissioner Rollin M. Dennistoun
Assistant Commissioner Darryl L. Anderson
Planning Director Randall Young

ENJOY THE HIGH QUALITY AND INFINITE VARIETY OF MINNESOTA FOODS

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Airports District Office
6301 34th Avenue South
Minneapolis, Minnesota 55450

SEP 20 1978

Mr. Richard B. Keinz, Director
Office of Development and Assistance
Mn/DOT-Division of Aeronautics
Transportation Bldg. Room 417
John Ireland Blvd.
St. Paul, Minnesota 55155

St. Paul Downtown Airport
St. Paul, Minnesota
Flood Wall Modification

Dear Mr. Keinz:

We have reviewed the Corp of Engineers' increased flood protection proposals for the Riverview Industrial Park submitted with your letter of September 15, 1978.

Our review, based on FAR Part 77 criteria, discloses that an increase in the levee elevation by more than three feet in the approach to runway 12 would create an obstruction to the 20:1 approach surface. An increase of more than one foot in the approach to proposed runway 14 would also create an obstruction to its 20:1 approach surface.

The point at which the levee penetrates the approach surface is at the closest point to the end of the primary surface. Consequently, other alternatives may be possible for providing flood protection. Our office would object to an increase of the levee that would penetrate Part 77 criteria. Also, we request that your office continue to coordinate this proposal with our office.

Sincerely,

LOREN R. BURCKHARDT
Chief, Planning Section

MINNESOTA HISTORICAL SOCIETY
690 Cedar Street, St. Paul, Minnesota 55101 • 612-296-2747

5 June 1978

Attention: Ray Sanford

Colonel Forrest T. Gay
District Engineer
St. Paul District
Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Gay:

RE: St. Paul, Minnesota
Flood Control Project

MHS Referral File Number D239

This letter is to inform you that Ms. Liza Nagle of my staff has toured the area encompassed by the draft plan of study concerning the St. Paul flood control project with Mr. Ray Sanford. The options for additional height to the levees and flood retaining walls in the Riverview Industrial Area were discussed.

The windshield survey of the project area reveals that it is unlikely that there are any properties of significance in the Riverview Industrial Area which will be affected by the flood control project. However, this office wishes to be informed when more detailed plans for the project have been defined.

Thank you for your continuing support for preserving Minnesota's cultural and historic resources.

Sincerely,

Russell W. Fridley
State Historic Preservation Officer

RWF/fr

FEASIBILITY REPORT

MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA

REEVALUATION OF

ST. PAUL FLOOD CONTROL PROJECT

DESIGN AND COST ESTIMATE

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ST. PAUL DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1981

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STRUCTURAL DESIGN

All existing structural features were analyzed for the 2-, 4-, and 8-foot raises. The soils data used in the review are the same as those used in the original design of the project. All features were analyzed for stability, creep, and structural adequacy. Wherever possible, the existing features were raised by adding additional concrete to the existing concrete for the 2-foot raise. For the 4- and 8-foot raises, new walls were designed. At the closure structures, additional slabs, riverward of the existing structure, were added to satisfy overturning stability and creep theory. Walls at pumping stations will be raised as necessary to provide access to the stations and to ensure that the stations will be operable during the design flood conditions. Plates 3-1 through 3-8 show designed barrier raises.

DETAILED COST ESTIMATE

Estimated costs have been compiled for the 2-, 4-, and 8-foot or standard project raises and are displayed in the following table. The detailed cost estimate for the recommended plan, the 4-foot raise, is shown in the next table. The unit costs are based on prices adjusted to reflect average bid prices received on similar work by the St. Paul District. The costs are based on July 1981 prices, and an additional allowance for contingencies of 20 percent has been added to the estimated costs. The estimated land costs per acre were obtained from unit prices for various land categories obtained from the city of St. Paul.

Comparison of costs for project raises

Item	2-foot raise	4-foot raise	8-foot raise (standard project flood)
Levees	$701,000	$1,097,000	$3,239,000
Removals and modifications	418,000	399,000	1,127,000
Roads and ramps	40,000	158,000	362,000
Drainage structures	57,000	468,000	1,097,000
Floodwalls	2,195,000	2,389,000	4,778,000
Closure structures	235,000	354,000	1,054,000
Pumping plants	39,000	260,000	1,294,000
Total construction costs	3,685,000	5,125,000	12,951,000
Engineering and design	387,000	539,000	1,360,000
Supervision and administration	240,000	333,000	842,000
Project beautification	74,000	102,000	[illegible]59,000
Lands	216,000	390,000	1,073,000
Acquisition costs	17,000	30,000	83,000
Total first cost	4,619,000	6,519,000	16,[illegible]68,000
Interest during construction	341,000	[illegible]1,000	1,[illegible]22,000
[illegible] investment	4,960,[illegible]	[illegible]	[illegible]

Detailed cost estimate, St. Paul flood control project, 4-foot raise

Item	Unit	Quantity	Unit cost	Total cost
Federal first costs				
Levees and floodwalls				
Levees				
Station 0+00 to station 3+00 Station 3+00 to station 12+45 Station 12+45 to station 34+63 Station 39+20 to station 41+05 Station 65+70 to station 67+90 Station 69+20 to station 73+80 Station 74+30 to station 80+20 Station 85+90 to station 102+00 Station 102+00 to station 112+10 Station 112+60 to station 118+10 Station 118+10 to station 142+15 Station 142+65 to station 151+50	[Varying levee sections: quantities below are summary totals]			
Stripping, 6-inch	CY	19,180	$2.20	$42,196
Gravel toe drain	CY	6,055	15.00	90,825
Impervious fill	CY	66,880	2.25	150,480
Random fill	CY	64,450	3.50	225,575
Drainage berm	CY	30,930	3.00	154,650
Riprap	CY	1,920	22.50	43,200
Bedding for riprap	CY	950	17.50	16,625
Topsoil	CY	8,420	7.20	60,624
Seeding	Acre	16.4	950.00	15,580
Sodding	SY	3,200	2.50	8,000
Sandbag closures:				
Station 1+30 ramp, 3 feet H	LF	64	105.00	6,720
Station 12+45 ramp "B", 3 feet H	LF	40	105.00	4,200
Station 29+00 ramp "C", 3 feet H	LF	50	105.00	5,250
Station 32+30 ramp "D", 3 feet H	LF	50	105.00	5,250
Station 40+00 ramp "E", 3 feet H	LF	30	105.00	3,150
Station 106+ramp	LF	50	105.00	5,250
Station 105+railroad closure	LF	30	105.00	3,150
Station 115+ramp roads, 3 feet H	LF	100	105.00	10,500
Station 116+ to 121 airport closure	LF	500	105.00	52,500
Station 151+frontage roads, 3 feet H	LF	100	105.00	10,500
Contingencies				182,775
Total levees				1,097,000

Detailed cost estimate, [illegible] project, [illegible] (cont)

[illegible] unit cost total cost

Detailed cost estimate, St. Paul flood control project, 4-foot raise (cont)

Item	Unit	Quantity	Unit cost	Total cost
Federal first costs (cont)				
Levees and floodwalls (cont)				
Drainage structures				
Cap existing manhole A and build new manhole A with surface drain	Job	Sum	-	$11,900
Relief well system, stations 16+00 to 33+50, 65+80 to 70+00, and 77+00 to 80+00	Job	Sum	-	329,600
Raise catch basin 1 (2 feet)	Job	Sum	-	500
Raise manholes F, H, and J (6 feet)	Each	3	$900.00	2,700
Modify existing collector system - station 70 to 77 (approximately) (raise five catch basins)	Job	Sum	-	5,600
Raise catch basins 34, 35, and 36 and regrade area to drain	Job	Sum	-	5,000
Modify gate well B	Job	Sum	-	4,300
Modify gate well D	Job	Sum	-	1,800
Modify gate well G	Job	Sum	-	1,800
Modify gate well K	Job	Sum	-	4,900
Modify gate well L	Job	Sum	-	6,800
Modify gate well M	Job	Sum	-	5,400
Modify gate well N	Job	Sum	-	4,800
Modify gate well O	Job	Sum	-	5,200
Contingencies				77,700
Total drainage structures				468,000
Floodwalls				
Station 41+05 to station 47+00 Station 47+16 to station 48+90 Station 49+92 to station 52+86 Station 53+73 to station 65+20 Station 67+70 to station 69+35 Station 79+75 to station 80+08 Station 80+85 to station 82+62 Station 83+00 to station 86+05	(Varying floodwall sections; quantities below are summary totals)			
Excavation and backfill	LF of wall	2,904	7.00	20,328
Remove existing CMP toe drain	LF of wall	1,844	2.00	3,688
Concrete (including cement)	LF of wall	2,904	205.00	595,320
Reinforcing steel	LF of wall	2,904	80.00	232,320

[illegible] $\frac{\text{cont}}{\text{Ev}}$ [illegible]

Detailed cost estimate, St. Paul flood control project, 4-foot raise (cont)

Item	Unit	Quantity	Unit cost	Total cost
Federal first costs (cont)				
Pumping plants (cont)				
Custer Street station				
Wall raise - 4-foot	LF	84	$100.00	$8,400
Railing and grating modifications	Job	Sum	-	5,000
Add partition walls	Each	3	6,000.00	18,000
Miscellaneous mechanical and electrical	Job	Sum	-	5,000
Chester Street station				
Wall raise, 4-foot	LF	116	100.00	11,600
Railing and grating modifications	Job	Sum	-	4,500
Miscellaneous mechanical and electrical	Job	Sum	-	5,000
Contingencies				45,000
Total pumping plants				260,000
Total construction costs				5,125,000
Engineering and design				539,000
Supervision and administration				
Inspection				231,000
Overhead				102,000
Total supervision and administration				333,000
Project beautification				102,000
*Real estate				
Lands				325,000
Contingencies				65,000
Acquisition costs				30,000
Total real estate				420,000
Total first costs				6,519,000
Interest during construction				481,000
Total project investment				7,000,000

(1) Asterisk indicates items requiring local cost sharing under traditional Corps policy.

ESTIMATE OF ANNUAL CHARGES

Annual charges for the proposed improvements are based on an interest rate of 7 3/8 percent and an amortization period of 100 years. Included in the annual charges is an allowance for interest during an assumed 2-year construction period. Maintenance and operation of the proposed improvements are based on cost data available for similar work throughout the country plus added maintenance attributable to the project modifications. Estimates of the average annual maintenance, operation, and replacement costs and a summary of the estimated annual charges for the flood protection plan at St. Paul are shown in the tables below.

Estimates of additional annual maintenance, operation, and replacement costs

Item	Annual cost
Replace pumps at Moses Street pumping station (1)	$2,000
Annual power charges	100
Levee maintenance	500
Pumping plant operation	400
Total	3,000

(1) Amortized costs based on 35-year life.

Estimated annual charges

Item	Annual charges
Total first cost	$6,519,000
Interest during construction	481,000
Total project investment	7,000,000
Interest and amortization (1)	517,000
Operation, maintenance, and major replacements	3,000
Total annual charges	520,000

(1) Interest and amortization for 100-year life at 7 3/8-percent interest rate = 0.07381.

COST SHARING

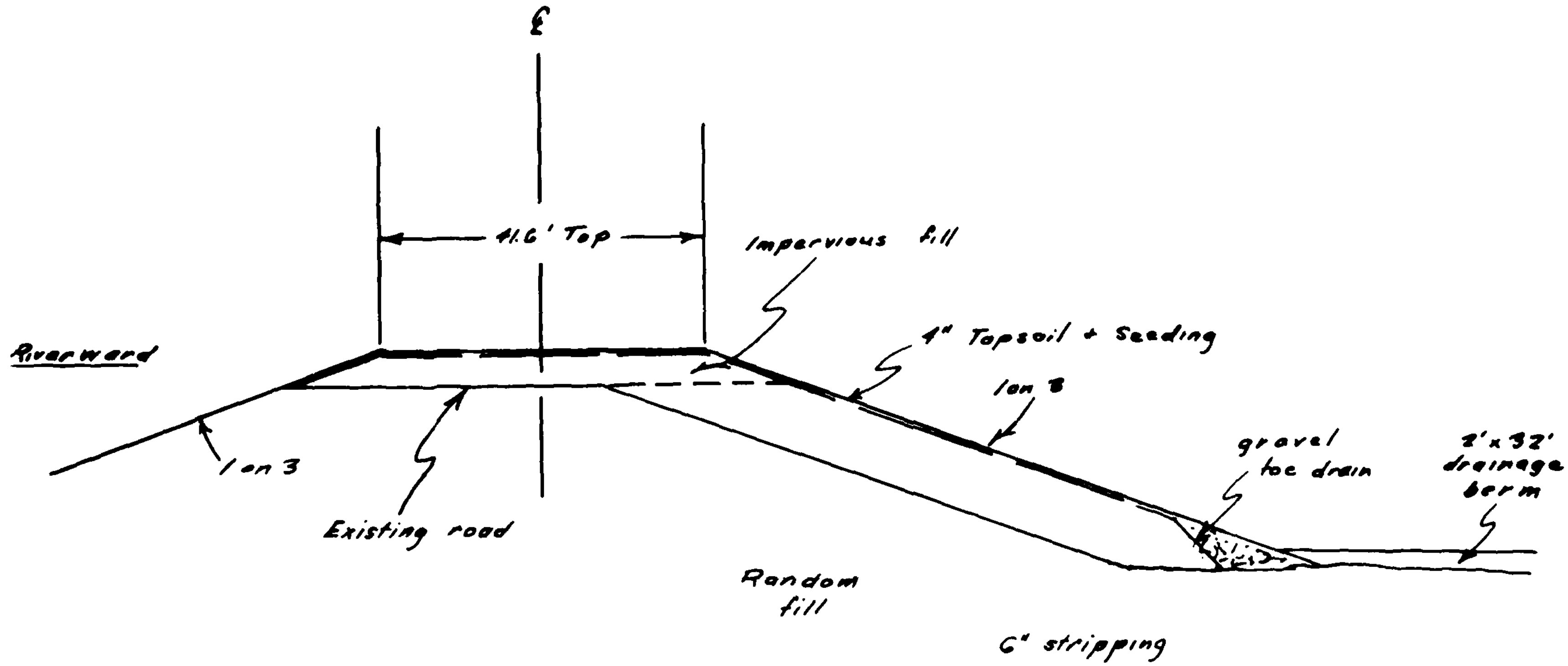
Under traditional Corps of Engineers policy established by the 1936 Flood Control Act, local interests are required to provide all lands, easements, rights-of-way, and all alterations and relocations to utilities, streets, etc.; hold and save the United States free from damages due to the construction works; and ensure operation and maintenance of the works after completion. The table below shows a Federal/non-Federal breakdown of costs detailed in tables on pages 3-2 through 3-7. Costs shown as non-Federal in the following table (under the traditional policy) are asterisked (*) for identification in the table on page 3-3. Non-Federal costs for streets and ramps include that part of the total cost required for resurfacing and for reconstructing curbs and gutters. All modifications to existing drainage structures are considered as Federal project costs because they are required for effective interior drainage and were originally constructed using Federal funds.

Also shown on the table below is the recommended administration's cost sharing as was first proposed by President Carter in 1979. Under the recommended policy the local sponsors would pay 20 percent of initial project costs and all operation and maintenance costs, and the State of Minnesota would pay 5 percent of initial project costs. The balance - 75 percent - would be the Federal share.

Cost sharing, 4-foot raise

Interest	Traditional policy	Recommended administration policy
Federal	$6,395,000	$5,370,000 (1)
City	605,000 (2)	1,304,000
State	-	326,000
Total project investment	7,000,000	7,000,000

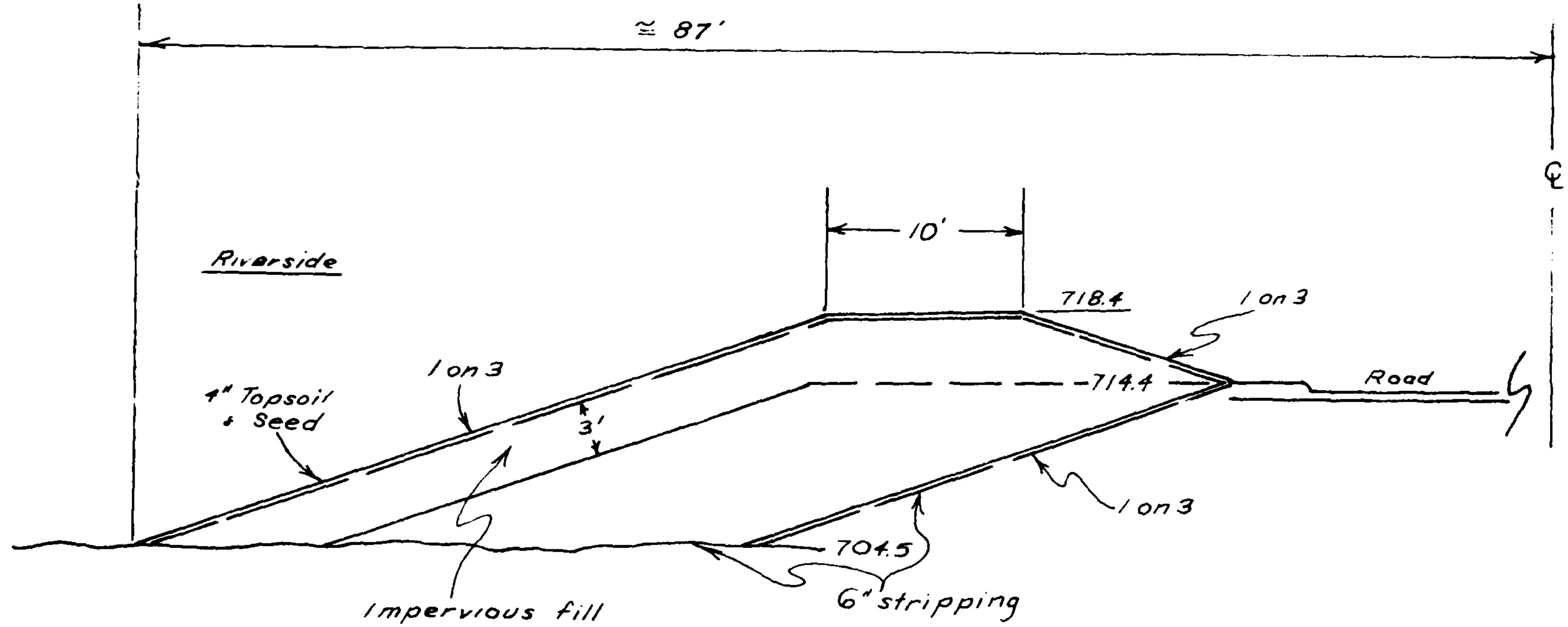
(1) Includes 75 percent of total first costs plus $481,000 interest during construction.
(2) Includes local share of interest during construction.



ST. PAUL FLOOD CONTROL

ROAD RAISE - 4 FOOT RAISE

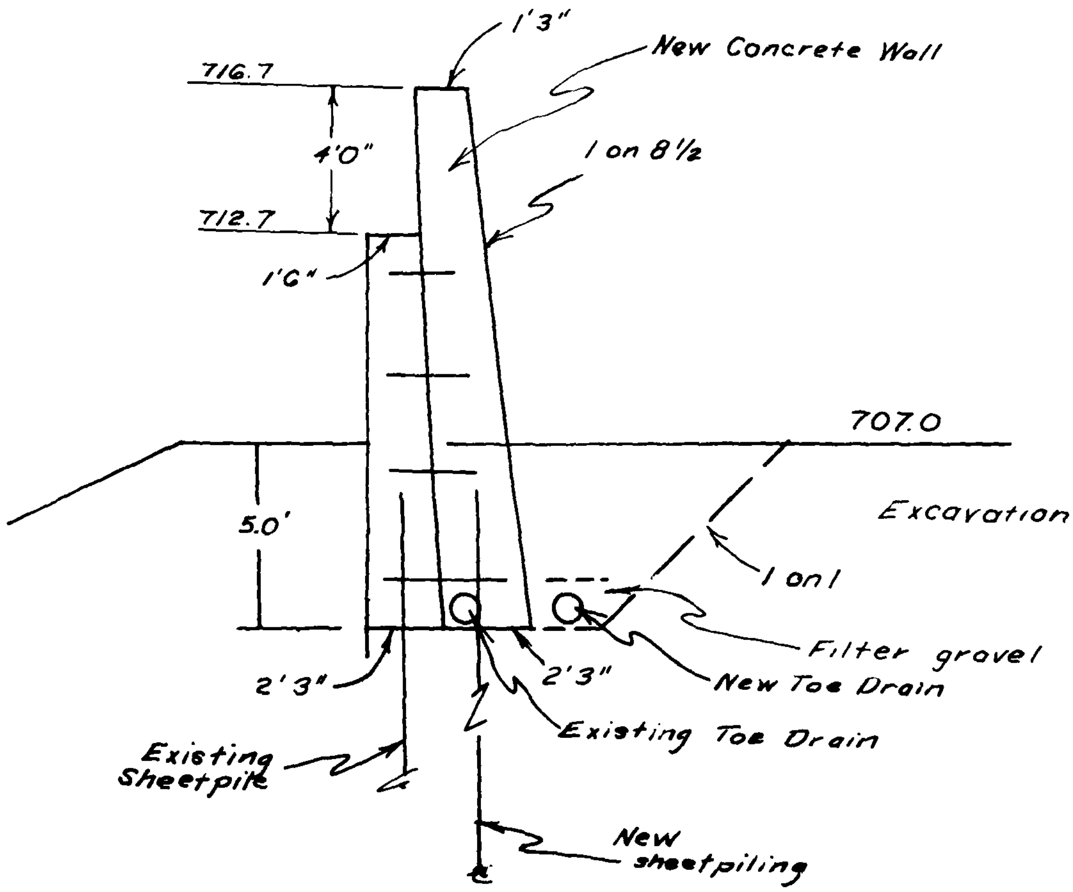
TYPICAL STATION 3+00 to 12+45 (levee)



ST. PAUL FLOOD CONTROL

LEVEE - 4 FOOT RAISE

Typical Station 12+45 to 33+00 (levee)

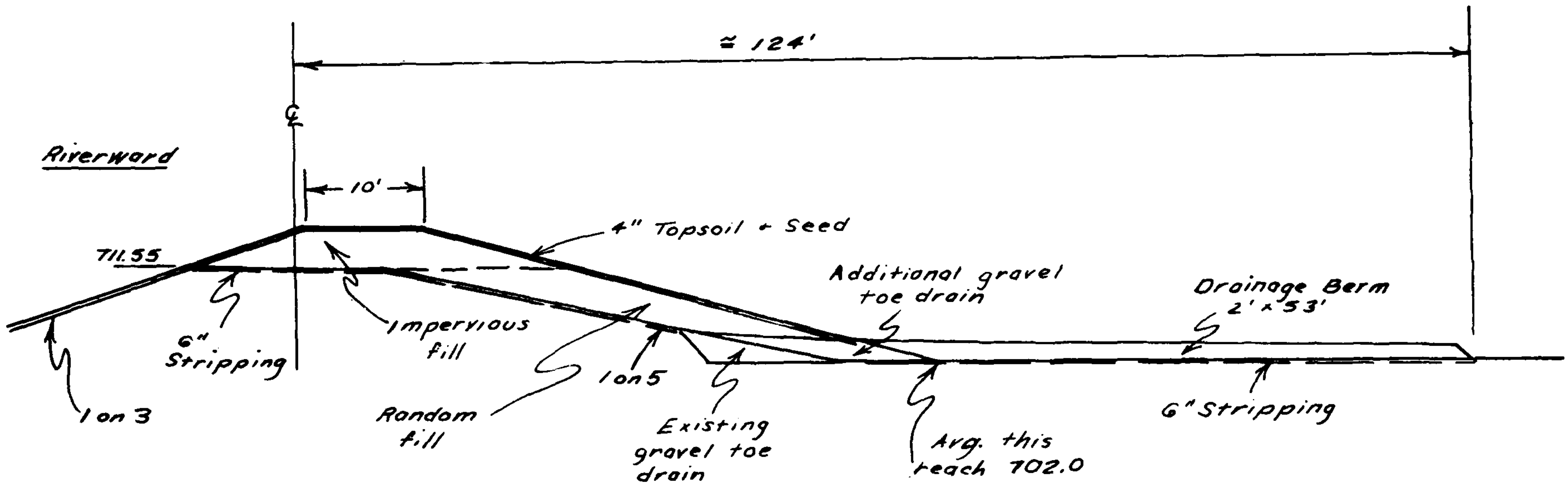


ST PAUL FLOOD CONTROL

LEVEE – 4 FOOT RAISE

Typical

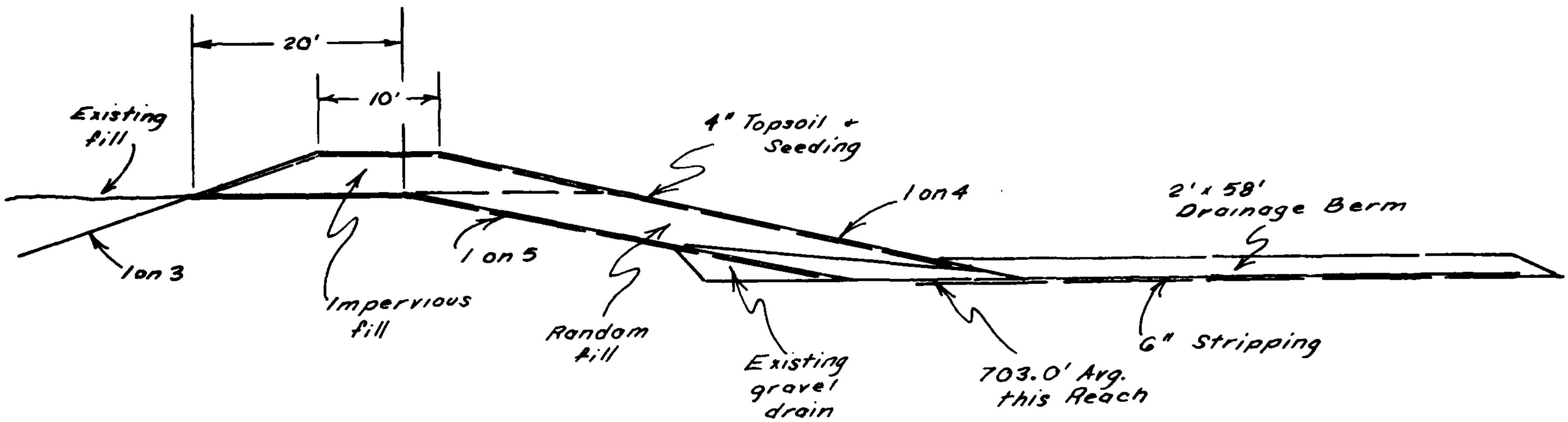
STATION 41+00 to 52+80 (floodwall)
67+74 to 69+32 (floodwall)
80+00 to 86+00 (floodwall)



ST. PAUL FLOOD CONTROL

LEVEE - 4 FOOT RAISE

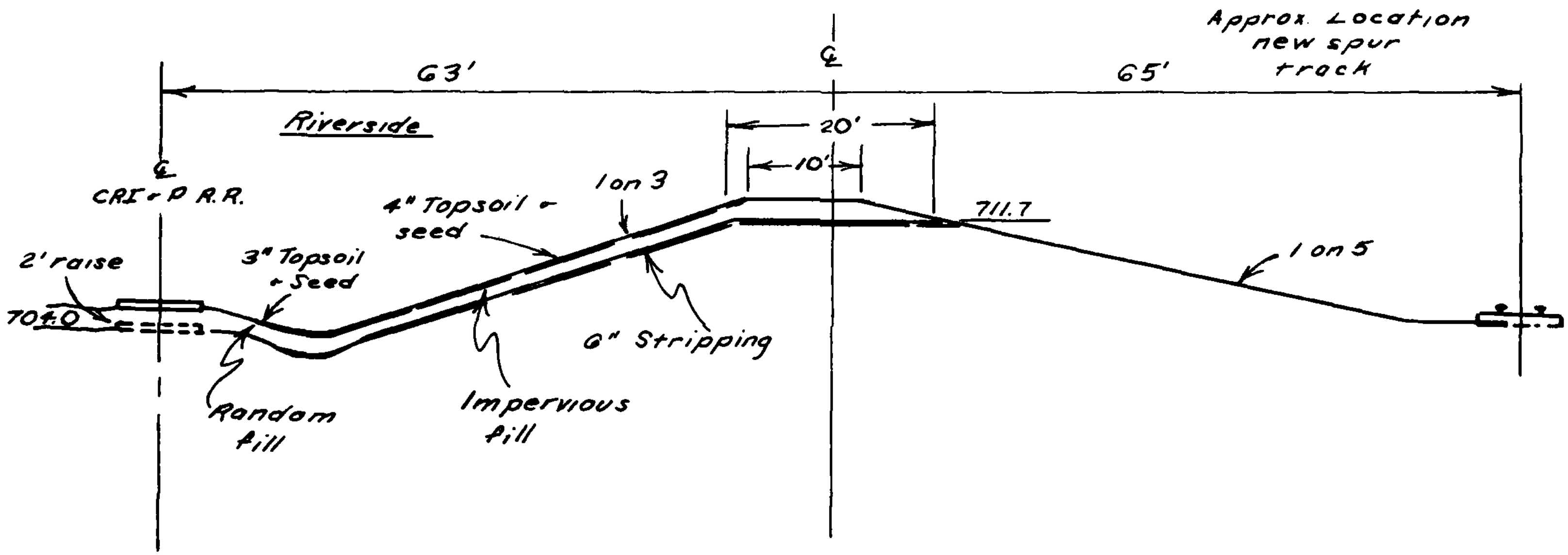
Typical Station 86+00 to 98+00



ST. PAUL FLOOD CONTROL

LEVEE - 4 FOOT RAISE

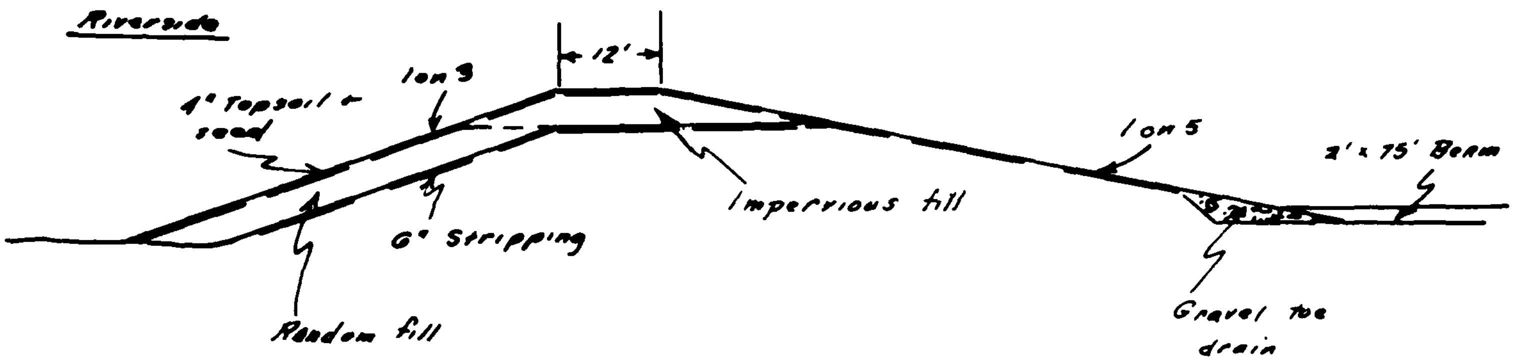
STATION 98+00 to 111+00 (levee)



ST. PAUL FLOOD CONTROL

LEVEE – 4 FOOT RAISE

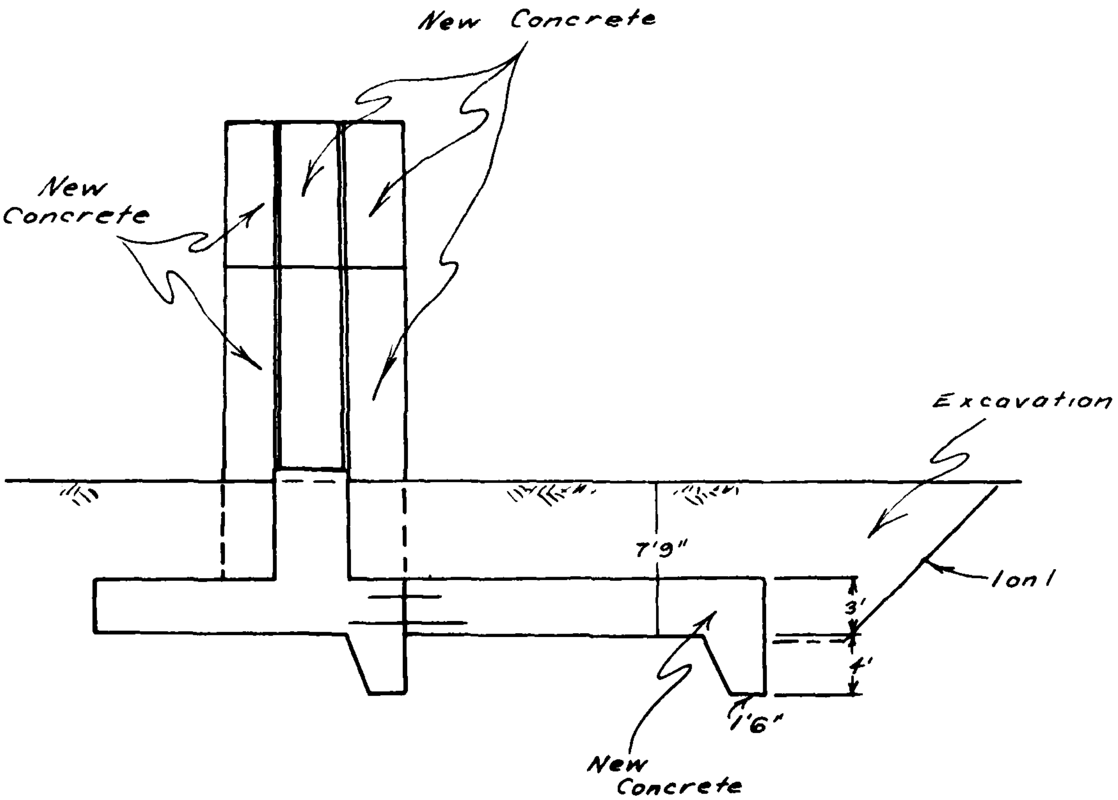
STATION 111+00 to 142+00 (Includes RR closure, street ramp, and airport approach closure - apply this section as appropriate)



ST. PAUL FLOOD CONTROL

LEVEE 4 FOOT RAISE

TYPICAL STATION 142+00 to 152+00 (levee)



ST. PAUL FLOOD CONTROL

LEVEE - 4 FOOT RAISE

CLOSURE STRUCTURES

FEASIBILITY REPORT

MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA

REEVALUATION OF

ST. PAUL FLOOD CONTROL PROJECT

HYDRAULIC DESIGN, SOILS AND GEOLOGY, INTERIOR DRAINAGE

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ST. PAUL DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1981

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GENERAL

1. The proposed project improvements include raising approximately 3 miles of combined levee and floodwall on the right bank (looking downstream) of the Mississippi River in St. Paul. The hydraulic design studies include the existing project design and considered 2-, 4-, and 8- (Standard Project Flood) foot flood barrier raise plans. Paragraphs 4 through 11 discuss the methods used in computing the design water surface profiles and also the hydraulic design considerations.

2. As part of the stage 3 final feasibility investigation, interior drainage studies of a preliminary scope were performed to determine the modifications to existing pumping stations and gravity flow features required with a flood barrier raise of 2 feet, a raise of 4 feet, and a raise up to the standard project flood level.

3. References

A list of references used in this study follows:

a. EM 1110-2-1601, "Hydraulic Design of Flood Control Channels."

b. "Erosion and Riprap Requirements at Culvert and Storm Drain Outlets," Research Report H-70-2, Waterways Experiment Station, Vicksburg, Mississippi.

c. "Hydraulic Design Criteria," Waterways Experiment Station, Vicksburg, Mississippi (Volumes 1 and 2).

d. AD-743 461, "Practical Guidance for Estimating and Controlling Erosion at Culvert Outlets," Waterways Experiment Station, Vicksburg, Mississippi, 1972.

e. "Erosion Control Measures at Storm Sewer and Culvert Outlets" Waterways Experiment Station, Vicksburg, Mississippi.

f. ETL 1110-2-230 "Hydrologic and Hydraulic Engineering for Survey and Investigations."

g. "Generalized Computer Program, HEO-2 Water Surface Profiles, Users Manual," prepared by Hydrologic Engineering Center, August 1979.

h. "General Design Memorandum No. 1 on Local Flood Protection for St. Paul and South St. Paul, Minnesota, Mississippi River," prepared by U.S. Army Engineer District, St. Paul, September 1959.

i. "General Design Memorandum No. 2 on Local Flood Protection for St. Paul and South St. Paul, Minnesota, Mississippi River, Project at St. Paul, Minnesota," U.S. Army Engineer District, St. Paul, April 1960.

j. "Plans and Specifications for the existing flood control project at St. Paul," U.S. Army Engineer District, St. Paul, May 1961.

k. USGS Water Data Reports: "Water Resources Data for Minnesota."

l. "Climatological Data," National Oceanic and Atmospheric Administration, Environmental Data Service, U.S. Department of Commerce.

m. "Invitation for Bids, Invitation No. CIVENG-21-018-61-32," dated 11 May 1961 (Project Specifications).

n. "Operation and Maintenance Manual, Flood Control Project on the Mississippi River at St. Paul, Minnesota," March 1964.

o. EM 1110-2-1410, "Interior Drainage of Leveed Urban Areas; Hydrology."

p. EM 1110-2-3102, "General Principles of Pumping Station Design and Layout."

q. EM 1110-2-3105, "Mechanical and Electrical Design of Pumping Stations."

r. TM 5-820-1, "Drainage and Erosion Control Surface Drainage Facilities for Airfields and Heliports."

s. TM 5-820-4, "Drainage for Areas Other than Airfields."

t. "Standards of the Hydraulic Institute, Twelfth Edition (1969)."

u. "Data Book for Civil Engineers - DESIGN," by Elwyn E. Seelys, Volume I.

v. Pump Installation Manuals for Johnston Vertical Pumps installed at the Moses Street and Custer Street Pumping Stations.

w. Pump Head-Discharge-Brake Horsepower-Efficiency Curves provided by the Fairbanks Morse Company for the pumps located in the Chester Street pumping station.

x. Pump Head-Discharge-Brake Horsepower-Efficiency Curves provided by the Johnston Pump Company for the pumps located in the Moses and Custer Street pumping stations and the curves presented on Page 18 of Section 5 of their catalog.

[illegible] Discharge-Brake Horsepower-Efficiency [illegible] Pump Company Catalog.

[illegible]

aa. "Interior Drainage Analysis for Flood Control Project, Minnesota River at Chaska, Minnesota," prepared for Department of the Army, St. Paul District, Corps of Engineers, by the Barr Engineering Company Consulting Engineers, Minneapolis, Minnesota.

bb. ETL-1110-2-120 "Additional Guidance for Riprap Protection."

cc. CIVENG-21-018-62-11, "Local Flood Protection Project," Stage 2. Flood Control Mississippi River, St. Paul, Minnesota.

dd. "Water Resources Development - Minnesota," NCE (1979).

HYDRAULIC DESIGN

4. Elevation-Discharge Rating Curves

The elevation-discharge rating curves shown on Plates 4-1 and 4-2 are for sites of existing U.S. Geological Survey stream gaging stations located at River Miles 833.7 and 839.3. The rating curve shown on Plate 4-1 for the River Mile 833.7 site was developed from recorded high water stages and discharge measurements for flows equal to or less than the 1965 flood of record. For discharges greater than the 1965 flood, the curve on Plate 4-1 was extended from detailed backwater computations. The location of the rating curve at River Mile 833.7 (Plate 4-1) is also the control point for regulation of Pool No. 2. The rating curves shown on Plate 4-2 for the River Mile 839.3 site were developed from backwater computations for the existing project conditions, the proposed raised flood barrier conditions, and the no flood barrier condition. Starting water surface elevations for detailed backwater computations are from the rating curve shown on Plate 4-1 (River Mile 833.7).

5. Bridge Clearance

Data on bridge characteristics are shown on Table 4-1. No bridge improvements are proposed under the plans considered. Five bridges are located across the Mississippi River within the limits of the St. Paul project. Three of these are major highway routes and have much more than 3 feet of clearance for the 1-percent chance and the existing project design flood. The other two bridges are located between Robert Street and Wabasha Street and have less than 3 feet of clearance for the 1-percent chance flood. One of these two is a bridge crossing the right side channel from the west (right) bank to Navy Island and does not

TABLE 4-1

BRIDGE DATA

Bridge	River Mile	Bridge Data Low Steel Elevation at Centerline of Channel	WATER SURFACE ELEVATION UPSTREAM OF BRIDGE WITH EXISTING AND PROPOSED RAISED FLOOD BARRIER: Existing Flood Barrier Project Design Flood (168,000 cfs)	Proposed Flood Barrier Raises: 2 Foot (187,000 cfs)	Proposed Flood Barrier Raises: 4 Foot (210,000 cfs)	Standard Project Flood (260,000 cfs)
Lafayette	838.75	742.7	709.1	710.8	712.6	716.3
Robert St.	839.25	746.7	709.7	711.3	713.1	716.8
CN&W RR (1)	839.30	711.4	710.0	711.7	713.6	717.4
Navy Island	839.43	701.3	710.0	711.7	713.7	717.7
Wabasha	839.45	727.0	710.2	712.0	713.9	717.9

(1) NOTE: This railroad bridge is a drawbridge. The center span can be raised so that the low steel elevation of the span in the raised position is 759.7

affect flow in the main channel. This bridge would be inundated by the 1-percent chance flood. The other bridge, a railroad lift bridge with a sloping bridge deck, just upstream of the Robert Street bridge has a low steel elevation on the right bank that is less than the 1-percent chance floodwater surface elevation. The center line and left bank low steel elevations for this bridge are higher than the right bank, but do not have 3 feet of clearance. However, the span over the main channel can be easily raised to elevation 759.7.

6. Water Surface Profiles

Water surface profiles for the project design flood and considered flood barrier raise alternatives were derived for this study by backwater computations utilizing the Hydrologic Engineering Center (HEC-2 Water Surface Profiles) Computer Program and an HEC-2 model developed by the Minnesota Department of Natural Resources that was further modified by the St. Paul District. The water surface profile used for the design of the existing flood control project, completed in 1963, is presented in "General Design Memorandum No. 1 on Local Flood Protection for St. Paul and South St. Paul, Minnesota, Mississippi River," St. Paul District, dated September 1959. The first major flood after construction of the existing flood control project occurred in 1965. This flood (171,000 cfs) is very close to the Design Flood (168,000 cfs) and verifies the 1960 Design Flood Profile. Another large flood occurred in 1969 (157,000 cfs) and is close to the 1-percent chance flood (151,000 cfs). The 1965 and 1969 floods were used to determine parameters for the HEC-2 model developed for this study. Roughness coefficients (Mannings "n" values) are shown on Table 4-2. Water surface profiles computed for flood barrier conditions include the existing Project Design (168,000 cfs) and the considered 2-, 4-, and 8- (Standard Project Flood (260,000 cfs)) foot raises. These profiles are shown on Plates 4-3 through Plate 4-6. A summary of the profiles developed is shown in Table 4-3. Areas flooded by the 1-percent chance flood (150,000 cfs), the proposed project design flood (210,000 cfs), and the standard project flood (260,000 cfs) for both existing conditions and the proposed 4-foot barrier raise conditions are shown on plates 4-15 and 4-16.

TABLE 4-2

Mannings Roughness Coefficients
("n" values)

Cross Section	River Mile	Left Overbank	Right Overbank	Channel	Contraction	Expansion
92 to 94	837.92 to 838.25	0.063	0.063	0.035	0.600	0.800
96 to 98.50	838.58 to 838.83	0.063	0.063	0.042	0.100	0.300
99 to 101.8	838.92 to 839.3	0.063	0.063	0.035	0.100	0.300
102 to 109	839.30 to 840.65	0.045	0.045	0.035	0.100	0.300
110 to 112	839.85 to 840.97	0.045	0.045	0.035	0.100	0.300

TABLE 4-3

Summary of Water Surface and
Top of Levee Profiles Developed

	Profiles developed Assuming Levees Hold	Profiles developed Assuming Levees Fail	Comments
Existing Project Without Proposed Project Condition (Plate 4-3)	1 Percent Chance Flood (150,000 cfs) Intermediate Regional Flood (160,000 cfs) Existing Project Conditions (168, 000 cfs)	Standard Project Flood (260,000 cfs)	Existing Levee Shown
Two Foot Barrier Raise (Plate 4-4)	1 Percent Chance Flood (150,000 cfs) Considered conditions design flood 2-foot barrier raise (187, 000 cfs)	Standard Project Flood (260,000 cfs)	Existing Levee and 2-foot raised levee shown
Proposed Four Foot Barrier Raise (Plate 4-5)	1 Percent Chance Flood (150,000 cfs) Proposed conditions design flood with 4-foot barrier raise (210,000 cfs)	Standard Project Flood (260,000 cfs)	Existing Levee and Proposed 4-foot Levee shown SPF not contained by this barrier raise
Standard Project Flood Protection (Plate 4-6)	1 Percent Chance Flood (150,000 cfs) Standard Project Flood (260,000 cfs)		Existing Levee and proposed Levee shown

All starting water surface elevations for backwater computations were determined from the rating curve at River Mile 833.7. Backwater computations were correlated with the rating curve at the USGS gage (River Mile 839.30).

7. Effect of Flood Barrier Raise on Upstream Water Surface Profiles

The effect of considered flood barrier raises at the Robert Street bridge (River Mile 839.3) is shown on the elevation-discharge rating curve on Plate 4-2. At this location, the increases in water surface elevation from the no flood barrier condition to the existing Project Design and the three considered flood barrier raises are 0.4 foot, 0.6 foot, 0.8 foot, and 1.1 feet, respectively. The increased stages at the upstream end of the proposed project (River Mile 840.05) with the proposed barrier raises are 0.4 foot, 0.63 foot, 0.85 foot, and 1.4 feet, respectively. The backwater effects would attenuate as they extend upstream to the tail water of Locks and Dam 1 (River Mile 847.5).

8. Closure Structures

The 13 closure structures for the existing project (8 stop log and 5 sandbag) will be upgraded to permit access for the use of roads and railroads during nonflood periods. The city of St. Paul coordinates the operation of the closure structures with the flood outlook issued by the National Weather Service approximately 2 weeks prior to flooding in St. Paul. This outlook is updated daily with a 3-day flood forecast. The National Weather Service has been able to predict the last two historic floods far in advance. Closing time for the largest closure structure (Closure Number 8) during the 1965 and 1969 floods was 4 days and 2 1/2 days, respectively. Present plans of the city propose that the size of Closure 8 be reduced. This will shorten the required closure times. Closure structures are shown on Plate 4-7.

9. Freeboard

The freeboard provided for the considered barrier raises is a minimum of 3 feet as required for earth levees (reference a). The minimum freeboard provided for existing conditions (with the 1961 flood control project) is 2.8 feet except for the reach just upstream of the Chicago and North Western Railroad bridge. An additional 1.0 foot of freeboard was provided in this

reach as an engineering judgment. The top of levee profiles for the proposed barrier raises were developed by backwatering a discharge corresponding to the water surface elevation 3 feet above the proposed design flood at the downstream end of the project. This was done to insure that if the levee is overtopped the overtopping would occur at the downstream end of the levee. The three proposed top of barrier profiles are shown on plates 4-4, 4-5, and 4-6.

10. Velocities

Computed channel and overbank velocities for the Mississippi River with existing and proposed conditions were determined from backwater computations using the HEC-2 computer program. Velocities adjacent to the levees were found to be less than 3 fps (feet per second), while those at center channel range from 6 to 8 fps. Computed velocities for the project design (168,000 cfs) and the proposed flood barrier raise plans are shown on Table 4-4.

11. RIPRAP PROTECTION

Riprap requirements for existing and considered conditions were computed using design criteria presented in EM 1110-2-1601 (reference a) and ETL 1110-2-120 (reference bb). Location of the existing erosion protection is shown on Plate 4-7. Typical sections for existing conditions are shown on Plate 4-8 with locations shown on Plate 4-7. Table 4-5 summarizes the location of riprap, layer thickness of riprap, and gradation of riprap for existing and considered conditions. Plate 4-9 shows riprap gradation curves for existing and considered conditions. In addition the gradation curve for existing riprap is shown on Plate 4-9. The curve for the existing riprap protection lies near the upper limit of the design band for considered levels of protection. Thus the existing erosion protection is sufficient for any of the considered conditions. A sample computation [illegible] riprap design is included at the end of this [illegible] for the [illegible] case which is at cross section 102 with [illegible] [illegible] section.

TABLE 4-4
CHANNEL VELOCITIES
(fps)

Cross Section	River Mile	Project Design Flood Existing Conditions (168,000 cfs)			Flood Barrier Raises								
					2-Foot (187,000 cfs)			4-Foot (210,000 cfs)			Standard Project Flood 7-Foot (260,000 cfs)		
		Left Overbank	Channel	Right Overbank	Left Overbank	Channel	Right Overbank	Left Overbank	Channel	Right Overbank	Left Overbank	Channel	Right Overbank
93	838.15	.8	6.1	1.4	1.0	6.2	1.5	1.1	6.3	1.5	1.4	7.1	2.0
94	838.25	0.9	6.5	1.4	1.1	6.9	1.6	1.3	7.3	1.7	1.8	8.1	2.1
95	838.40	1.2	6.0	1.5	1.3	6.7	1.7	1.5	7.0	1.8	2.3	7.6	2.2
96	838.58	1.1	6.1	1.5	1.4	6.4	1.7	1.6	6.8	1.8	2.2	7.5	2.2
97	838.75	1.1	6.2	1.3	1.4	6.6	1.5	1.7	7.0	1.7	2.2	7.7	2.2
98	838.80	1.2	6.3	1.1	1.4	6.7	1.3	1.7	7.2	1.6	2.3	7.9	2.1
99	838.92	1.0	6.7	1.1	1.2	7.2	1.2	1.5	7.7	1.4	2.0	8.6	1.8
100	839.10	1.1	6.7	1.5	1.3	7.1	1.7	1.6	7.7	1.9	2.1	8.7	2.3
101	839.20	1.1	6.0	1.2	1.3	6.4	1.3	1.5	6.9	1.5	1.9	7.9	1.9
102	839.30	2.0	7.0	1.8	2.2	7.5	1.9	2.5	8.0	2.1	3.2	8.7	2.7
103	839.40	2.1	7.1	3.0	2.3	7.5	3.2	2.6	7.8	3.4	3.3	8.2	3.9
104	839.50	1.8	5.6	1.8	1.9	6.0	2.1	2.0	6.3	2.3	1.8	6.8	2.8
105	839.70	2.2	6.9	2.0	2.2	6.8	1.9	2.2	7.0	2.4	2.0	8.1	3.1
106	839.85	2.1	6.7	2.1	2.2	6.8	2.2	2.5	7.7	2.6	1.8	7.7	3.2
107	840.05	1.8	5.8	2.0	1.9	6.2	2.2	2.2	6.5	2.5	1.6	6.7	2.9
108	840.25	1.7	5.2	2.6	2.1	6.0	2.3	2.0	6.0	2.5	1.5	6.1	3.4
109	840.40	1.9	5.3	2.1	2.2	5.7	2.3	2.3	6.0	2.6	1.6	6.1	2.8
110	840.65	1.9	5.8	1.5	2.7	6.1	2.2	2.9	6.5	2.4	1.4	6.9	2.2

TABLE 4-5

Riprap Protection

Condition	Location (Stationing Shown on Plate 4-7)	Layer Thickness (Inches)	Riprap Gradation
Existing Project (1961 Project)	44+00 to 100+00	12	Refer to Plate 4-9
2-Foot Flood Barrier Raise	"	"	"
4-Foot Flood Barrier Raise	"	"	"
SPF Protection Condition	"	"	"

12. Sedimentation

Sedimentation has not been a problem within the limits of the St. Paul Project in the past. St. Paul is in the limits of the 9-Foot Channel Project on the Mississippi River between the Missouri River and Minneapolis. Authorized in the River and Harbor Act of July 3, 1930, the Upper Mississippi River 9-Foot Channel Project, with the exception of the upper 4.6 miles (St. Anthony Falls extension), has been in operation since 1940. The 9-Foot Channel Project maintains an adequate controlling depth of 9 feet for navigation. Sedimentation in areas such as outlets receives minor local maintainance which permits proper project functioning.

INTERIOR DRAINAGE

13. Required Interior Drainage Modifications

Based on a preliminary analysis, the existing gravity design facilities associated with the St. Paul Flood Control Project appear to be of adequate hydraulic capacity without any modifications. With a proposed [illegible] foot raise in the [illegible] [illegible]

14. With a 2-foot raise in the flood barrier, the only required modifications are a raise in the required gate closure levels and maximum sump levels in the Moses and Custer Street pumping stations to a 10.0-foot stage and the adjustment of the pitch (angle) of the pump impellers in the Moses Street station from +1.5 to +2.0. In the Operation and Maintenance Manual prepared in March 1964, it was recommended that the gates on the gravity outlets not be closed nor pumping operations initiated until the river reaches a 10.0-foot stage.

15. With the proposed 4-foot raise in the flood barrier, the required modifications are a raise in the required gate closure levels and maximum sump levels in the Moses and Custer Street pumping stations to a 10.0-foot stage and replacement of the pumps in the Moses Street station. The new pumps must be capable of discharging about 17,200 gpm (gallons per minute) each at a 22-foot (dynamic) head. The new pumps should be similar to the 24-inch, 700-rpm (revolutions per minute), mixed-flow pump with impeller diameter A presented in the Aurora Pump catalog on page 421 of Section 1160.

16. With a flood barrier raise up to the standard project flood level, the pumps and motors in the Moses and Custer Street stations would have to be replaced and the intercepting storm sewers in several locations would have to be moved landward to permit construction of a new flood barrier. The existing pumps and motors located in the Chester Street station are of adequate capacity. The specific changes in the Moses and Custer Street pumping stations required with a flood barrier raise to the standard project flood level are as follows:

a. Raise the gate closure level and maximum sump level in each station to a 10.0-foot stage.

b. Replace the two pumps in the Moses Street station with two pumps capable of discharging about 17,700 gpm each at a 26-foot head. The 24-inch, 700-rpm mixed-flow pump with impeller diameter A presented in the Aurora Pump catalog on page 421 of Section 1160 appears to meet this requirement.

c. Replace each of the four pumps in the Custer Street station with pumps capable of discharging about 15,100 gpm at a 25.1-foot head. The 24-inch, 700-rpm, mixed-flow pump with impeller diameter B presented in the

Aurora Pump catalog on page 421 of Section 1160 appears to meet this requirement.

d. Replace each of the two pump motors in the Moses Street station with new 150-horsepower, 700-rpm motors and the four motors in the Custer Street station with new 125-horsepower, 700-rpm motors.

17. Following are the estimated lengths and average depths of stormwater interceptor sewer which would have to be relocated with a flood barrier raise to the standard project flood level:

Pipe Size and Type	Estimated Length in feet	Average Depth in feet
12" RCP	256	6
15" RCP	230	5
18" RCP	397	8
21" RCP	1175	8
24" RCP	1334	9.5
30" RCP	283	10.5

Also requiring relocation would be 26 catch basins and a drainage ditch from about Station 85+70 to Station 93+50.

18. Present Drainage

Except for a portion of the protected area in the southeast corner, the location and size of the contributing watersheds and runoff characteristics are assumed to be the same as presented in the General Design Memorandum No. 2, dated April 1960. Since 1964 when the project was constructed, a new express highway (LaFayette Freeway) has been constructed through the eastern portion of the protected area and some light industry and commercial establishments have located adjacent to the highway.

The existing stormwater sewage system has also been extended to the southeast corner of the protected area and, therefore, probably eliminated the need for pumping facilities in this area. The contributing watersheds to the three existing pumping stations and to the outlet at Closure Structure No. 8 are shown on Plate 4-10 and further described as follows:

a. Moses Street Watershed - All land below the bluff, east of the line of protection and west of Wabasha Street, less about 16 acres.

b. Custer Street Watershed - All land north and east of Wabasha and Concord Streets, south and west of Robert Street and the C&NW Railway track, and west of the LaFayette Freeway, plus about 16 acres west of Wabasha Street.

c. Chester Street Watershed - All land east of Robert Street and north of Plato Street, east of the LaFayette Freeway and south of Plato Street, plus about 40 acres between Robert Street and the Freeway and south of Plato Street. Overland flow from this 40-acre area will flow to the south and east and either 1) discharge into the extended stormwater sewer system and then flow to the north to the Chester Street outlet or 2) continue to flow overland to the outlet at Closure Structure No. 8.

d. Watershed to Outlet at Closure Structure No. 8 - About 63 acres located adjacent to the Closure Structure plus a portion of the 40 acres located north thereof.

19. The sanitary sewage system in the older developed areas is combined with the stormwater system and in the newer developed areas is a separate system. One 1000-gpm sewage pump is currently located in each of the three existing stormwater pumping stations to remove sanitary sewage during periods of high river stages. During low river stages when the sanitary sewage flows directly to the sanitary lift station, these pumps are used to remove stormwater runoff and prevent the unnecessary use of the larger stormwater pumps. These pumps are also used to drain the sump chambers following a flood period.

20. Ponding Areas and Elevation-Damage Relationships

For the purpose of this study, it is assumed that there are no ponding areas available and that the volume of open stormsewer available for the temporary storage of rainfall runoff is negligible. Elevation-damage relationships were not considered during this study.

21. Degree of Protection

The entire area is considered to be Class II Urban development, as defined in EM 1110-2-1410.

22. River and Discharge Stage Data

The daily discharge in the Mississippi River at St. Paul has been recorded since 1892. The U.S. Geological Survey gaging station is currently located along the left bank of the river about 300 feet upstream from the Robert Street bridge. A discharge rating curve and a discharge-duration curve for the Mississippi River at the gage are shown on Plates 4-2 and 4-11, respectively. Gage zero is equivalent to an elevation of about 684.16 based on USGS datum, 1912 adjustment. The periods between 1 October 1939 and 30 September 1980 during which the river equaled or exceeded a 10-foot, 14-foot and a 15-foot stage at the Robert Street gage are presented in Table 4-6.

23. Rainfall Data

Historical rainfall data were obtained from the U.S. Department of Commerce publication: "Climatological Data" for the Natural Weather Service gages located at the Minneapolis-St. Paul International Airport and at the St. Paul airport (Holman Field). Daily rainfall amounts from 1939 through 1980 were obtained from the St. Paul gage. Hourlv rainfall records were obtained from both gages. Hourly rainfall data are available for the St. Paul gage from 1950 through 1952 and for the Minneapolis gage from 1950 to the present. The hourly rainfall amounts for all events of 0.3 inch or more and which occured at St. Paul when the Mississippi River was at or above the 10-foot stage level are presented in Table 4-7. The hourly values for the events from 1953 through 1980 obtained for the Minneapolis gage were adjusted to match the total recorded rainfall at St. Paul. The total rainfall which occurred during the period when the river was at or above the 10-foot, 14-foot and 15-foot stages between 1939 and 1980 are presented in Table 4-6.

24. The theoretical 50-year, 100-year and standard project storm rainfall data used in the evaluation of gravity flow conditions were developed for a recent flood control study at Chaska, Minnesota, located about 27 miles west of St. Paul. Hourly rainfall amounts were obtained from the point rainfall-duration curves presented on Plates E2 and E3 of the Barr Engineering Report (reference 3aa) which were based on criteria established in EM 1110-2-1410 (reference 3o). Rainfall excess amounts were

TABLE 4-6
PERIODS OF BLOCKED GRAVITY DRAINAGE
AT ST. PAUL (1939-1980)

RIVER STAGE: 10.0
DISCHARGE: 43,000cfs

YEAR	DATES FROM	DATES TO	NUMBER OF DAYS	TOTAL RAINFALL (INCHES)	PEAK DISCHARGE IN RIVER (CFS)
1943	Apr 4	Apr 12	9.4	0.26	58,200
	Jun 16	Jun 26	10.4	0.01	54,500
1944	May 9	May 30	20.6	2.81	51,600
	Jun 7	Jun 27	20.6	2.45	56,900
1945	Mar 21	Mar 27	6.2	0.79	52,900
1947	May 4	May 8	4.0	0.44	46,500
1948	Mar 31	Apr 3	3.0	0.16	46,500
1950	May 9	May 27	19.0	0.89	53,700
1951	Apr 11	May 12	30.9	1.72	92,700
1952	Apr 7	May 7	30.8±	1.44	124,000
1953	Jun 27	Jun 30	3.3	2.00	46,600
	Aug 13	Aug 16	3.3	0.16	46,200
1957	Jun 24	Jul 8	15.0	2.36	78,400
1962	Apr 7	Apr 18	11.0	0.93	56,200
	May 27	Jun 3	8.0	1.07	53,000
1965	Apr 10	May 14	34.7±	4.48	171,000
	May 31	Jun 3	2.3	5.01	48,800
	Jun 4	Jun 18	13.3	1.60	53,400
1966	Mar 21	Mar 27	5.3	1.20	49,000
1967	Apr 2	Apr 13	10.0	0.81	52,100
1968	Oct 23	Oct 31	8.3±	0.14	58,200
1969	Apr 6	May 13	36.7	2.41	154,000
1971	Apr 7	Apr 17	9.3	0.07	49,500
1972	Mar 24	Mar 31	7.0	0.27	51,400
	Jul 26	Jul 31	4.4	1.04	48,600
1973	Mar 17	Mar 25	7.6	0.20	51,600
1975	Apr 22	May 15	24.0	6.82	78,100
1979	Apr 3	May 22	49.8	5.14	75,400
RIVER STAGE: 14.0					
DISCHARGE: 66,500 cfs					
1951	Apr 13	Apr 24	11.6	0.67	92,700
1952	Apr 9	Apr 29	19.5	0.37	124,000
1957	Jun 27	Jul 3	5.0	0.10	78,400
1965	Apr 11	May 1	20.2	2.57	171,000
1969	Apr 9	Apr 30	21.1	1.40	154,000
1975	Apr 29	May 9	10.1	1.05	78,100
1979	Apr 22	Apr 28	7.4	0.22	75,400
RIVER STAGE: 15.0					
DISCHARGE: 72,500 cfs.					
1951	Apr 13	Apr 23	9.7	0.67	92,700
1952	Apr 10	Apr 27	17.1	0.37	124,000
1957	Jun 28	Jul 2	3.1	0.04	78,400
1965	Apr 11	Apr 29	18.7	2.57	171,000
1969	Apr 10	Apr 28	18.5	1.40	154,000
1975	May 2	May 7	5.1	0.21	78,100
1979	Apr 23	Apr 25	3.6	0.11	75,400

obtained using the method presented in Appendix C of EM 1110-2-1410. The total loss ratios are based on an average loss rate for the maximum 6-hour period, high temperatures, and average soil conditions.

25. Unit and Runoff Hydrographs

Sixty-minute unit hydrographs for the four contributing watersheds were developed using the Horton overland flow equation and are presented in Table 4-8. The parameters used to develop the unit hydrographs are presented in Table 4-9. The size of the contributing watersheds, previously discussed in paragraph 17, were obtained from USGS topographic maps. The retardance coefficients shown in Table 4-9 are the weighted average values based on land use and type of ground cover in the area. Each watershed was first subdivided relative to land use. The type of ground cover was then determined assuming residential areas consist of 20 percent building and 80 percent average grass, railroad areas consist of 5 percent pavement and 95 percent bare pack soil, school areas consist of 90 percent building or pavement and 10 percent average grass, commercial and industrial areas consist of 50 percent building or pavement and 50 percent bare soil, and open areas consist entirely of average grass. The retardance coefficients for the various types of ground covers were assumed as 0.02 for smooth pavement or building, 0.10 for bare packed soil and 0.40 for average grass. The assumed distribution of land uses in each of the four contributing watersheds is presented in Table 4-10. The average ground levels and travel distances used to determine the effective slope are presented in Table 4-11. A rainfall excess of 1.95 inches per hour is the estimated total 96-hour amount for the 30-year coincident storm with gate closure at the 10-foot stage.

26. Rainfall runoff hydrographs for all rainfall events of 0.3 inch or more which occurred at St. Paul when the Mississippi River was at a stage of 10 feet or greater for each of the four contributing watersheds were obtained, but are not presented in this report. Table 4-12 presents the estimated peak runoff rate obtained for each event.

TABLE 4-[illegible]

COINCIDENTAL HOURLY RAINFALL AM[illegible] AT [illegible]

STORMS OF RECORD (0.3 Inches or Greater)

Date	MAY 16 1950	APR 20-21 1951	MAY 1 1951	APR 21 1952	MAY 7 1952	JUN 27 1953	JUN 26 1957	JUL 4 1957	JUL 8 1957	APR 12-13 1962	MAY 29-30 1962	APR 11-12 1965	APR 15 1965	APR 23 1965	APR 25-26 1965	MAY 6-7 1965	MAY 7-8 1965	MAY 8-9 1965
Total Rainfall in Inches	.54	.63	.59	.36	.65	2.00	.81	.72	.61	.64	.89	.41	.31	.88	.71	.91	.46	.48
Hour of Commencement	11	17	1	5	7	6	1	1	1	1	1	1	1	1	[illegible]	21	24	24
Hour 1	.02	.01	.03	.03	.03	.04	.54	.29	.32	.01	.41	.10	.02	.06	-	.05	.01	[illegible]
2	.05	.05	.14	.02	.05	.51	.02	.22	.29	.04	.06	.02	.03	.47	.01	.31	.03	.06
3	.05	.10	.14	-	.05	.46	-	.21		.07	.02	-	-	.35	.02	.06	.06	.08
4	.03	.06	.12	-	.07	.83	-			.08	-	-	.05		.02	.20	.11	.02
5	.05	.04	.02	-	.08	.12	.20			.08	-	-	.04		.03	-	-	
6	.09	.05	-	-	.13	-	.05			.08	-	-	.03		.05	-	-	
7	.02	.03	-	-	.09	-				.03	-	-	.01		.04	-	-	
8	.01	.02	-	-	.06	-				.05	-	-			.04	-	-	
9	.08	.01	-	-	.05	-				.05	-	-			.02	-	-	
10	.10	.01	-	-	.04	-				.03	-	-			.04	-	.01	
11	.03	.02	-	.02		-				.03	-	-			.04	-	[illegible]	
12	.01	.02	-	.03		.04				.05	-	-			.04	.29	[illegible]	
13		.02	-	.02						.03	-	.09	.05		.05		.01	
14		.03	-	.08						-	-	.06	.06		.05			
15		.05	-	.11						.01	-	.03	.02		.09			
16		.04	-	.03							-	.05			.05			
17		.01	-	.02							-	.02			.05			
18		-	-								-				.05			
19		-	-								-				.02			
20		-	.02								-							
21		-	.07								-	.01						
22		.04	.04								.40							
23		.02	-															
24			.01									.01						
25												.01						
26																		
27																		
28																		
29																		
30												.01						
31																		
32																		
33																		

TABLE 4-8
60-MINUTE UNIT HYDROGRAPHS
(CFS)

Time (hours)	Moses	Custer	Chester	C.S. #8
0.5	11	39	33	14
1.0	35	112	101	37
1.5	45	127	130	38
2.0	36	82	101	22
2.5	22	41	61	10
3.0	12	18	32	4
3.5	6	8	16	1
4.0	3	3	8	0
4.5	1	1	4	
5.0	0	0	2	

TABLE 4-9

HORTON PARAMETERS

Station	Moses	Custer	Chester	C.S. #8
Area (Acres)	86	216	244	63
Time Interval (min.)	30	30	30	30
Retardance Coef.	.196	.085	.09	.085
Effective Length (feet)	3800	7700	6300	3600
Effective Slope (ft/ft)	.00492	.00809	.0031	.00265
Rainfall Excess (in/hr.)	1.95	1.95	1.95	1.95
Time Lag (min.)	60	60	60	60

These runoff rates were obtained from the runoff hydrographs developed by combining the rainfall amounts presented in Table 4-7 with the unit hydrographs presented in Table 4-8 and assuming 80-percent runoff. Discharge-frequency curves prepared by plotting the peak inflow rates presented in Table 4-12 against the appropriate Weibull plotting point are presented on Plates 4-12, 4-13, and 4-14. Due to the preliminary nature of this study and the existing or proposed high degree of development, the determination of infiltration on an hourly basis during blocked gravity conditions was not considered.

27. Seepage and Snowmelt

The estimated rates of seepage to each of the three pumping stations (per foot of head) are presented in Table 4-13. The estimated seepage rates at the designated locations in Table 4-13 (lines 1 through 4) were obtained from Plates 4-6 through 4-10 of Appendix A, General Design Memorandum, dated April 1960. Line 5 in Table 4-13 is equal to line 2 less line 3, and line 6 is equal to line 4 divided by line 5. Snowmelt is not considered.

28. Gravity Outlets and Stormwater Interceptors

All gravity outlets and stormwater intercepting sewers appear to be of adequate capacity; however, with the plan requiring a flood barrier raise to the standard project flood level, a portion of the interceptor sewer system would have to be relocated landward to permit construction of the new flood barriers. The required relocations are identified in paragraph 16.

29. The adequacy of the gravity design features was determined based on their satisfactory operation during the storm of 30-31 August 1977, the maximum recorded rainfall event in the St. Paul area. The estimated interior pond levels resulting from the runoff during the design 50-year storm were not investigated, except in the area adjacent to Closure Structure No. 8.

TABLE 4-10

LAND USE DISTRIBUTIONS

Location	Composite Retardance Coefficient based on land use	Assigned Land Use Distribution in Percent			
		Moses	Custer	Chester	Closure Structure No. 8
Type of land use					
Residential	0.32	0	9	0	0
Railroad	0.10	0	5	5	5
School	0.06	0	5	0	0
Commercial-Industrial	0.06	60	81	87	88
Open	0.40	40	0	8	7
Average Retardance Coefficient		0.196	.085	.09	.085

TABLE 4-11

AVERAGE GROUND LEVELS AND TRAVEL DISTANCES

Location	Moses	Custer		Chester	C.S. #8
Elevation at point of beginning	706	750	706	707	706
Elevation at pump station	687.3	706	687.7	687.5	697
Estimate travel distance in feet	3800	1800	5900	6300	3600
Average Slope in ft/ft.	.00492	.00809*		.0031	.00265

*Based on a total length of 7700 feet.

TABLE 4-12

PEAK RUNOFF RATES IN CFS

Storm of 0.3-inch or greater with 80 percent runoff

Location of Contributing Watershed / Date of Storm	Moses Street	Custer Street	Chester Street	Closure Structure No. 8	Chester Street & Closure Structure No. 8 Combined
16 May 1950	5.6	14.4	15.2	4.0	19.2
20-21 April 1951	4.8	13.6	14.4	4.0	18.4
1 May 1951	8.8	22.4	24.8	6.4	31.2
21 April 1952	5.6	15.2	16.8	4.8	20.8
7 May 1952	7.2	18.2	20.8	5.6	26.4
27 June 1953	41.6	112.0	118.4	33.6	151.2
26 June 1957	20.0	55.2	56.8	16.0	72.8
4 July 1957	15.2	38.4	42.4	11.2	53.6
8 July 1957	17.6	46.4	49.6	15.2	64.8
12-13 April 1962	5.6	14.4	16.8	4.0	20.8
29-30 May 1962	15.2	42.4	43.2	12.8	56.0
11-12 April 1965	4.0	11.2	12.0	3.2	15.2
15 April 1965	3.2	9.6	10.4	3.2	13.6
23 April 1965	24.0	62.4	67.2	18.4	85.6
25-26 April 1965	4.8	12.8	13.6	4.0	17.6
6- 7 May 1965	12.8	34.4	36.0	10.4	46.4
7- 8 May 1965	8.0	22.4	23.2	6.4	29.6
8- 9 May 1965	12.0	34.4	34.4	10.4	44.8
15-16 May 1965	16.8	47.2	48.8	14.4	60.0
31 May 1965	19.2	52.8	54.4	16.0	70.4
31 May-1 June 1965	48.8	126.4	137.6	38.4	175.2
6 June 1965	27.2	76.0	77.6	23.2	100.8
23-24 March 1966	12.0	29.6	32.0	8.8	40.8
1- 2 April 1967	22.4	60.8	65.6	17.6	83.2
6- 7 April 1967	14.4	36.8	39.2	11.2	50.4
15 April 1969	3.2	10.4	11.2	4.0	14.4
27-28 April 1969	11.2	28.8	32.0	8.8	40.8
26 July 1972	16.8	41.6	45.6	12.8	58.4
23 April 1975	16.0	41.6	46.4	12.8	55.2
27-28 April 1975	41.6	116.0	120.0	34.4	154.4
7 May 1975	14.4	36.0	39.2	11.2	49.6
30 April 1979	3.2	8.0	8.0	2.4	10.4
2 May 1979	7.2	20.8	21.6	6.4	28.0
9 May 1979	8.0	20.8	22.4	6.4	28.0
10 May 1979	10.4	29.6	30.4	8.8	39.2
11 May 1979	16.8	46.4	48.8	14.4	62.4
18 May 1979	23.2	60.8	66.4	17.6	84.8
20 May 1979	9.6	27.2	28.0	8.0	36.0

TABLE 4-13

SEEPAGE RATES

1	Location of Test Hole (Station)*	22+00	42+00	76+50	81+50	89+00
2	Design River Level*	711.3	710.8	709.1	709.1	708.9
3	Tailwater Level Landward of Levee*	702.9	702.0	703.0	702.0	700.5
4	Seepage Rate in GPM Per Foot of Levee*	1.8	2.6	0.6	0.95	0.29
5	Head in Feet (Line 2 less Line 3)	8.4	8.8	6.1	7.1	8.4
6	Estimated Seepage Rate in GPM Per Foot of Head Per Foot of Levee (Line 4 divided by Line 5)	0.214	0.295	0.098	0.134	0.035
7	Estimated Length of Levee in Feet subject to Given Seepage Rate	3450	3175	1275	625	-

8	Location of Watershed	Moses Street	Custer Street	Chester Street
9	Estimated Length of Flood Barrier in Feet	3450	2005	9200
10	Weighted Seepage Rate in GPM Per Foot of Head Per Foot of Levee	0.214	0.295	0.084
11	Estimated Seepage Rate Per Foot of Head in GPM	783	591	773

*Obtained from General Design Memorandum, dated April 1960 - Appendix A, Plates A-6 through A-10.

30. During the evening of 30 August and early morning of 31 August 1977, a flash flood occurred in the Minneapolis-St. Paul area. The recorded rainfall and estimated rainfall excess for this event are presented in Table 4-14. (Also included in the table are the estimated hourly rainfall from a theoretical 50-year, 100-year and standard project storm and a comparison of these storms with the design 50-year storm). Based on an intensity-duration-frequency statistical study, the Minnesota State Climatologist has estimated the point rainfall frequency for this storm to be about a 200-year event. Note the maximum 5-hour accumulated rainfall of 30 August 1977 is about 85 percent of the 5-hour amount for the standard project storm. According to a representative of the sewer department for the city of St. Paul, there was no interior ponding nor resulting damages within the protected area during this storm.

31. In comparing the 100-year and standard project storms with the 50-year storm, note that the estimated amounts of rainfall and rainfall excess for a 100-year storm with a duration of 2 hours or less are only about 15 percent greater than those for the 50-year storm. (The estimated time of concentration in the St. Paul project is 2 hours or less). Also, note the accumulated rainfall excess for the standard project storm up to a 2-hour duration is only about 40 to 60 percent greater than that for the 50-year storm. The increased rainfall and rainfall excess for durations longer than 2 hours are not factors in the determination of peak runoff discharges.

32. Relative to the runoff from the design 50-year storm in the area adjacent to Closure Structure No. 8, a study was made to determine if the existing capacity of the outlet at Closure Structure No. 8 combined with the inflow to the new storm sewer extension would be great enough to satisfactorily remove the runoff from the 50-year storm. (Since completion of the project, a portion of the area located adjacent to Closure Structure No. 8, which was to be used for the temporary storage of rainfall runoff, has been filled. However, the city storm sewer system has also been extended to the southeast toward said outlet.) Based on an average water level in the streets of about

TABLE 4-14

COMPARISON OF RAINFALL INTENSITIES DURING STORM OF

30 AUGUST 1977 AND THEORETICAL 50-YEAR, 100-Year

AND STANDARD PROJECT STORMS

[illegible]ulated rainfall (inches) *				Accumulated rainfall excess (inches)				Percent exceeding 50-year event					
								Total rainfall			Rainfall excess		
50-yr	100-yr	SPS	30 Aug	50-yr	100-yr	SPS	30 Aug	100-yr	SPS	30 Aug	100-yr	SPS	30 Aug
2.08	2.45	2.90	2.12	2.05	2.42	2.86	-	18	39	2	18	40	-
2.58	2.95	3.64	2.82	2.53	2.90	3.57	-	14	41	9	15	41	-
3.05	3.44	5.08	4.48	2.96	3.35	4.91	-	13	67	47	13	66	-
3.36	3.75	6.37	5.98	3.23	3.62	6.04	-	12	90	78	12	86	-
3.59	4.00	7.52	6.68	3.42	3.83	7.00	-	11	110	81	12	104	-
3.77	4.20	8.57	7.27	3.51	3.99	7.83	-	11	127	86	12	123	-
3.92	4.35	9.53	-	3.67	4.10	8.54	-	11	143	-	12	133	-
7.46	8.15	14.25	-	5.08	5.58	10.62	-	9	91	-	10	109	-

[illegible]ulated amounts shown are the maximum recorded intensities at the Minneapolis-St. Paul International [illegible], located about 7.5 miles west of the project area. (Based on a isohyetal map prepared for this storm, [illegible] accumulation in the project area was between 6 and 7 inches.)

702.0, the estimated capacity of the outlet at Closure Structure No. 8 is 72 cfs. At this same level the estimated capacity of the new storm sewer extension is about 33 cfs which combined would have a capacity of about 105 cfs. The estimated peak runoff from a 50-year storm is about 94 cfs.

33. Since the amount of runoff from a 100-year or standard project storm is not significantly greater than that for the project design 50-year event, additional gravity design studies were not performed. The St. Paul protected area is similar to the Winona, Minnesota, protected area (relatively flat and almost completely developed), and the gravity flow features of the interior drainage plan at Winona were designed to satisfactorily remove runoff from a 50-year storm. The rainfall amounts used at Winona are approximately the same as those that apply to the St. Paul area. Recently completed studies have indicated that damages expected from a 100-year storm in the Winona area would be negligible and damages from a standard project storm would be within acceptable limits. Experience has also shown that modifications to existing interior drainage systems are not incrementally justified.

PUMPING STATIONS

34. Existing Conditions

There are currently three pumping stations located within the protected area to remove stormwater runoff during periods of blocked gravity drainage: the Moses Street station located near River Mile 839.8, the Custer Street station located near the Robert Street bridge at River Mile 893.4, and the Chester Street station located near River Mile 838.8. Each of the three pumping stations is constructed with a short horizontal discharge line projecting through the back wall where the outflow discharges into a discharge chamber. There is a flap gate located at the end of each discharge pipe to prevent backflow during high river stages. The original design capacities of each station are as follows:

a. Moses Street Station - two pumps, each with a capacity of about 14,100 gpm at a total dynamic head of 20.9 feet and about 20,100 gpm at a 6.0-foot head.

b. Custer Street Station - four pumps, each with a capacity of about 11,200 gpm at a total dynamic head of 19.3 feet, and about 21,100 gpm at a 6.0-foot head.

c. Chester Street Station - four pumps, each with a capacity of about 24,300 gpm at a total dynamic head of 17.8 feet, and about 28,000 gpm at a 4.7-foot head.

35. The gates on the gravity outlets at the Moses and Custer Street stations are currently closed when the river reaches a 6.0-foot stage, supposedly to prevent river water from backing up into the city's sanitary sewer system. [illegible] sanitary and storm sewer systems are currently

combined in these areas.) When the project was completed and turned over to the city in 1963, it was recommended that the outlet gates be closed when the river reaches a stage of 10.0 feet and that the pumps also commence operation at this level. A representative from the city's sewer department recently indicated that the current gate closure levels of 6.0 feet in the Moses and Custer Street areas could be raised to the 10-foot stage without creating a major backwater problem. The current maximum sump (operating) levels in the Moses and Custer Street stations are 6.5 feet and 6.8 feet, respectively. Normal river stage in the area is about 3.0 feet. Since the required station capacity and maximum operating heads at the Chester Street station appear to be more than adequate, a detailed investigation of current operating conditions at this station was not performed.

36. When the Mississippi River reaches a 15-foot stage, the outlet at Closure Structure No. 8 is closed. When pumping of stormwater runoff from this area becomes necessary, the city of St. Paul has in the past installed a 10-inch diesel pump to remove storm runoff and a 6-inch pump to remove seepage. A 10-inch and a 6-inch pump with about a 10-foot head will have a capacity of about 900 gpm and 600 gpm, respectively.

DETERMINATION OF REQUIRED MODIFICATIONS TO PUMPING STATION

37. The required modifications to the existing stormwater pumping stations are presented in paragraphs 13 through 15. Table 4-15 presents the design data used to determine the required modifications based on the 2-foot, 4-foot, and standard project flood barrier raises. Also presented in Table 4-15 is the estimated discharge capacity of each station with the recommended modifications.

38. If modification to the existing facilities was found to be necessary, the first alternative solution considered was to raise the maximum sump level to a 10-foot stage level. The second alternative was to adjust the angle of the pump impeller, if possible, to increase the head-discharge relationships. The third alternative was to replace only the pump and

TABLE 4-1[illegible]

PUMPING STATION [illegible] DATA

Line	Item	Moses Street Existing	Moses Street 2' Raise	Moses Street 4' Raise	Moses Street To [illegible]	Canton Street Existing	Canton Street 2' Raise	Canton Street 4' Raise	Canton Street To [illegible]	[illegible] Street Existing	[illegible] Street 2' Raise	[illegible] Street 4' Raise	[illegible] Street To [illegible]
1	Station Location	Moses Street				Canton Street				[illegible] Street			
2	River Mile (From Ohio River)	839.4				8[illegible]9.4				[illegible]			
3	Design Condition	Existing	2' Raise	4' Raise	To [illegible]	Existing	2' Raise	4' Raise	To [illegible]	Existing	2' Raise	4' Raise	To [illegible]
4	Design River Level at Pumping Station - USGS (a)	[illegible]	713.70	[illegible]	718.32	[illegible]	712.44	714.80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	- Gage	24.[illegible]	29.34	[illegible]	[illegible]	[illegible]	28.48	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	Selected Gate Closure Level - USGS (b)	[illegible]	[illegible]	[illegible]	694.4	[illegible]	694.2	[illegible]	[illegible]	[illegible] (f)	[illegible]	[illegible]	[illegible]
7	At Pumping Station - Gage	[illegible]	[illegible]	[illegible]	10.0	6.0	10.0	[illegible]	[illegible]	14.0	[illegible]	14.0	[illegible]
8	Maximum Pump Level Assumed - USGS (b)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	694.2	[illegible]	[illegible]	[illegible] (f)	[illegible]	[illegible]	[illegible]
9	- Gage	[illegible]	10.0	[illegible]	10.0	6.8	10.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	Peak Rainfall Inflow (Maximum Historical Event) - cfs (c)	[illegible]	[illegible]	[illegible]	48.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	- gpm	[illegible]	21,900	[illegible]	21,900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	Design Static Head In Feet (Line 4 less Line 8)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	Estimated Seepage Head In Feet (Line 12 divided by 4)	[illegible]	4.78	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	Estimated Seepage Rate in gpm per Foot of Head (d)	[illegible]	[illegible]	[illegible]	[illegible]	531	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	Design Seepage Rate in gpm (Line 13 times Line 14)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	Design Station Capacity in gpm (Line 11 plus Line 15)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	Pump Data: Number of Pumps in Station	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	4
18	(Existing Conditions) Pump Speed in RPM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	Pump Horsepower Available (g)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	Impeller Angle in Degrees	[illegible]				[illegible]							
21	Required Capacity in gpm (e)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	Size of Discharge Pipe in Inches	[illegible]	[illegible]	[illegible]	30	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	Length of Discharge Pipe in Feet (Horizontal) (h)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	Pump Data (i): Pump Capacity in gpm Based on Design Static Head	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	(Proposed Conditions) Velocity of Flow in Discharge Pipe in Feet per Second	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	Velocity Head in Feet	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	Total Dynamic Head in Feet (j)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	Pump Efficiency in Percent	[illegible]	[illegible]	[illegible] (m)	[illegible] (m)	[illegible]	[illegible]	[illegible]	[illegible] (n)	[illegible]	[illegible]	[illegible]	[illegible]
29	Required Brake Horsepower (pump)	[illegible]	[illegible]	[illegible]	[illegible] (m)	[illegible]	[illegible]	[illegible]	[illegible] (n)	[illegible]	[illegible]	[illegible]	[illegible]
30	Required Motor Horsepower (rated)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	Required Impeller Angle in Degrees		[illegible]			[illegible]	[illegible]	[illegible]					
32	Required Modifications: Adjust Angle of Pump Impeller		x										
33	Replace Pump			x	x				x				
34	Replace Motor			x	x				x				

(a) Based on latest stream profiles (see Plates 4-[illegible] through 4-[illegible]).
(b) USGS level is the level at the pump station; Gage level represents the level at the gage. [illegible] gage level is equivalent to USGS level 684.16 at the gage.
(c) Assumed [illegible] percent runoff.
(d) From Table A-1[illegible].
(e) Line 16 divided by Line 17; [illegible]
(f) Assumed level.
(g) Rated motor horsepower, [illegible]
(h) Obtained from [illegible]
(i) Number of pumps, pump speed, [illegible]
(j) Line 12 [illegible]
(k) Obtained from pump [illegible]
(l) Obtained from pump curve [illegible]
(m) Obtained from pump curve A, [illegible]
(n) Obtained from pump curve B, [illegible]
(o) Represents the combined inflow [illegible]

retain the existing pump motors. The last alternative was to replace both the pumps and motors. The selection of the Aurora brand of pump as a suggested replacement was an arbitrary selection and is not intended to indicate that this brand of pump is the only acceptable pump available. The possibility of meeting the higher pumping head requirements by changing the pump speed or nozzle diameter or the diameter of the discharge pipes was considered, but found to be unsatisfactory.

DETERMINATION OF REQUIRED STATION CAPACITIES

39. This study used the peak historical coincidental rainfall event for the preliminary investigation of required interior drainage modifications, and a probabilistic or a detailed period of record analysis was not performed. The pumping stations with proposed modifications have been designed to discharge at the maximum sump level, the peak rate of runoff from the maximum historical rainfall since 1950 which occurred with a river stage of 10.0 feet or more, plus an average seepage rate. The estimated peak runoff from the maximum coincidental rainfall was obtained from Table 4-12. The average seepage rate was assumed to be equal to the design static head (design flood level less maximum sump level), times 25 percent, times the composite seepage rate per foot of head obtained from Table 4-13. A 25-percent value is used to adjust for the variation in water levels along the landward side of the flood barrier and a variation in seepage heads (change in interior ground level) along the line of protection.

40. The size of the existing pumping station was based on a design discharge rate that would satisfactorily remove the runoff from a 30-year coincidental storm at minimum head and a maximum annual (1 year) event at maximum head. The required pumping rates at each station based on these criteria were presented in paragraph 34.

41. By designing the pumps to discharge the estimated peak runoff rate from the maximum coincidental storm of record, the selected pumps will have adequate capacity to prevent the ponding of interior runoff above the maximum sump level and result in only minor average annual flood damages

from interior runoff for events exceeding the historical record. The volume of storage available for ponding of interior runoff, consisting only of some open space and streets, is considered to be minor. Plates 4-12, 4-13, and 4-14 present the Weibul discharge-frequency relationships for the peak historical rainfall runoff rates presented in Table 4-12 at each pumping station.

42. Additional Work to be Performed for General Design Memorandum

Future studies will include refinement of the interior drainage hydrology, development of elevation storage (pondage)-damage relationships, update of peak seepage rates, incorporation of snowmelt runoff, and the completion of a period of record-economic pumping station design analysis assuming a 4-foot raise in the flood barrier. Refinement of the interior drainage hydrology will include review of and, if necessary, modification of watershed boundaries, unit hydrographs, and rainfall runoff hydrographs incorporating a more realistic streamflow and rainfall records and reevaluation of coincident and all-year rainfall-frequency data considering both an all-year and a partial duration basis.

GEOLOGY AND SOILS

GEOLOGY

43. The project is located in the extensive alluvial floodplain of the Mississippi River. A detailed description of the topography and geology is contained in the General Design Memorandum No. 2 on the Local Flood Protection for the St. Paul Project, dated April 1960.

STABILITY

44. The proposed sections were assumed to be stable with adequate strength to resist sliding or settlement because the proposed raise would add little weight and the foundation soils are predominantly sands. Settlement may be a problem at the downstream structure.

SEEPAGE

45. Seepage and possible uplift pressures will be the major soils problem for any raise which might be constructed. A preliminary study of possible seepage problems was made based on the soils data and design contained in General Design Memorandum No. 2, observed seepage during the 1965 and 1969 floods, and observed topography changes in the area landward of the barrier. Sheet pile and berms required in the existing barrier were assumed to have been designed at the minimum allowable safety factor; therefore, any raise would probably require an increase in length or thickness of these features. A preliminary seepage analysis was performed based on Bligh's and Lane's creep ratios and escape gradient criteria. The study was broken into reaches. Within each reach a section was chosen based on past observed seepage conditions during high water. The following results were obtained.

(1) Reach from station 0+00 to station 35+00 (levee).

a. For a 2-foot raise, using a 1 on 4 backslope, the existing gravel drain should be extended 20 feet beyond the toe of the new slope (later referred to as drainage berm with 2-foot thickness).

b. For a 4-foot raise, 1 on 4 backslope, a 32-foot drainage berm.

c. For a 6-foot raise, 1 on 4 backslope, a 45-foot drainage berm with collector.

(2) Reach from station 41+00 to station 65+00 (floodwall).

a. 2-foot raise, 16-foot sheet pile with cap connected to the toe of the existing floodwall (later referred to as sheet pile, implying cap connection).

b. 4-foot raise, 22-foot sheet pile.

c. 6-foot raise, 28-foot sheet pile.

(3) Reach from station 80+00 to station 86+00 (floodwall).

a. 2-foot raise, 26-foot sheet pile.

b. 4-foot raise, 32-foot sheet pile.

c. 6-foot raise, 38-foot sheet pile.

(4) Reach from station 65+00 to station 80+00 and station 86+00 to station 18+00 (levee).

a. 2-foot raise, 1 on 5 backslope, 45-foot drainage berm.

b. 4-foot raise, 1 on 5 backslope, 58-foot drainage berm.

c. 6-foot raise, 1 on 5 backslope, 70-foot drainage berm.

(5) Reach from station 118+00 to 142+00 (levee). - No work for seepage control is required as the raise and seepage cutoff will be constructed on the riverward face of the barrier.

(6) Reach from station 142+00 to station 151+37 (levee).

a. 2-foot raise, 1 on 5 backslope, 50-foot drainage berm.

b. 4-foot raise, 1 on 5 backslope, 75-foot drainage berm.

c. 6-foot raise, 1 on 5 backslope, 95-foot drainage berm.

The above designs were used in the proposed 4-foot raise plan with the exception of the reaches from stations 16+00 to 33+50, 65+80 to 70+00 and 77+00 to 80+00 where relief wells were used to limit costly real estate acquisition which would be required if berms were constructed.

OTHER FACTORS

[illegible] the barrier has been [illegible] drainage system. [illegible]

is apparent that there are insufficient borings at or landward of the levee toe or floodwalls to adequately define the foundation soil profile. Because this profile is critical to the design, additional exploration and study will be needed to insure that the design has an adequate safety factor. In the area downstream of station 118+00, considerable overexcavation might have occurred during construction; therefore, a boring or two through the levee will be needed to insure that the clay cap over the underlying deep sand strata was not broken. There also may be a problem with settlement at the closure structure located in this reach. The possibility exists that, for one or more reaches of the floodwall, the sheet piling may have been seated in or penetrated a deep clay layer. If this condition is found or verified by borings, there may not be a need to extend the sheet piling as the seepage would have been effectively cut off. A review of seepage quantities and the use being made of the area may require installation of collector pipes to intercept the seepage rather than the existing surface drains.

EROSION PROTECTION

47. The erosion protection will be an extension or replacement of the existing riprap. The existing riprap has been in place for several years, has been tested with flows greater than it was designed to withstand, and is adequate as designed, as indicated in paragraph 11, page 4-9.

CONSTRUCTION MATERIALS

48. Ample borrow material (sand or clay), stone for riprap, and concrete aggregate are available in the general area. The material will be similar to that used in the existing project, which does not show signs of undue weathering or other failure.

MISSISSIPPI AT ST. PAUL RIPRAP STUDY CONSIDERING A DISCHARGE=SPF=260,000 CFS

CROSS-SECTION NUMBER:	102.000
NUMBER OF SUBSECTIONS:	17
WATER SURFACE ELEVATION:	52.30
TOTAL DISCHARGE:	260000 CFS
DISCHARGE SUMMATION:	260000.0 CFS
AREA SUMMATION:	28705.15 SF
AVERAGE VELOCITY:	9.06 FPS

SPECIFIC WEIGHT OF STONE= 165 PCF

RIPRAP GRADATION
LAYER THICKNESS = 12 INCHES

PERCENT LIGHTER BY WEIGHT (SSD)	LIMITS OF STONE WEIGHT - LBS	
100	86	35
50	26	17
15	13	5

WRITE RESULTS OF THE ALPHA METHOD TO THE TERMINAL ?
I>YES

S7225260 OUTPUT
RUN DATE : 81/07/02. RUN TIME: 05.17.42.

=============================
-RESULTS OF THE ALPHA METHOD-
=============================

SUBSECTION NUMBER	XDIST R $CR^{1/2}$	DD R/K $(CR^{1/2})A$	AREA C $(CR^{1/2})^3 A$	K Q $(CR^{3/2})A$	F V
1	10.00 4.68 140	13.40 8.08 18849	134.00 64.99 372963139	.58 279.82 88299	28.00 2.09
2	70.00 37.16 574	39.55 64.07 1591687	2768.50 94.31 ***********	.58 23628.76 59148803	74.50 8.53
3	70.00 46.53 679	47.05 93.06 2237521	3293.50 99.60 ***********	.50 33216.23 104110655	70.78 10.09
4	30.00 42.04 636	42.05 84.0[illegible] 802[illegible]	1261.50 [illegible].16 ***********	.50 11919.[illegible] [illegible]1	30.00 9.45
5	60.00 37.9[illegible] 595	[illegible] [illegible] 1[illegible]	[illegible].00 [illegible] ***********	.5[illegible] [illegible] [illegible]	60.5[illegible] [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

9	70.00 35.21 567	36.55 70.42 1452109	2558.50 95.65 ◆◆◆◆◆◆◆◆◆◆◆◆	.50 21556.71 51127846	72.67 8.43
10	40.00 26.80 475	26.80 53.60 509376	1072.00 91.79 ◆◆◆◆◆◆◆◆◆◆◆◆	.50 7561.75 13651296	40.00 7.05
11	30.00 30.44 516	38.05 60.88 589418	1141.50 93.59 ◆◆◆◆◆◆◆◆◆◆◆◆	.50 8749.98 17941908	37.50 7.67
12	60.00 44.30 658	44.80 88.61 1769547	2688.00 98.90 ◆◆◆◆◆◆◆◆◆◆◆◆	.50 26269.11 78398639	60.67 9.77
13	30.00 39.78 614	39.80 79.56 733301	1194.00 97.38 ◆◆◆◆◆◆◆◆◆◆◆◆	.50 10885.54 29169209	30.02 9.12
14	45.00 40.71 623	40.80 81.42 1144559	1836.00 97.71 ◆◆◆◆◆◆◆◆◆◆◆◆	.50 16991.10 46594553	45.10 9.25
15	50.00 39.02 606	39.30 78.04 1191921	1965.00 97.10 ◆◆◆◆◆◆◆◆◆◆◆◆	.50 17694.19 46508846	50.36 9.00
16	45.00 30.55 506	31.30 52.68 712708	1408.50 91.54 ◆◆◆◆◆◆◆◆◆◆◆◆	.58 10580.22 21776549	46.10 7.51
17	1.00 .50 23	13.15 .86 309	13.15 33.30 171549	.58 4.60 154	26.32 .35

MEAN ENERGY SLOPE = .0002204 FT/FT
MEAN HYDRAULIC RADIUS = 40.50 FT
AVERAGE SHEAR STRESS = .56 PSF
ENERGY CORRECTION FACTOR (ALPHA): 1.04

ALPHA NEGLECTED:
MEAN C = 95.87
EFFECTIVE K = .57 FT
MANNING'S N = .029

ALPHA CONSIDERED:
MEAN C = 97.57
EFFECTIVE K = .50 FT
MANNING'S N = .028

-SHEAR STRESS COMPUTATIONS-

TABULATION OF DEPTHS AND VELOCITIES IN SUBSECTIONS
FOR USE IN DETERMINING LOCAL BOUNDARY SHEAR STRESS

SUBSECTION NUMBER	LEFT DEPTH	RIGHT DEPTH	AVERAGE DEPTH	VELOCITY (FPS)
1	0.00	26.80	13.40	2.09
2	26.80	52.30	39.55	8.53
3	52.30	41.80	47.05	10.09
4	41.80	42.30	42.05	9.45
5	42.30	34.30	38.30	8.85
6	34.30	44.30	39.30	8.42
7	44.30	50.30	47.30	10.16
8	50.30	46.30	48.30	10.27
9	46.30	26.80	36.55	8.43
10	26.80	26.80	26.80	7.05
11	26.80	49.30	38.05	7.67
12	49.30	40.30	44.80	9.77
13	40.30	39.30	39.80	9.12
14	39.30	42.30	40.80	9.25
15	42.30	36.30	39.30	9.00
16	36.30	26.30	31.30	7.51
17	26.30	0.00	13.15	.35

COMPUTATION FOR LEFT BANK ?
1>NO

COMPUTATION FOR RIGHT BANK ?
1>YES

ENTER DEPTH AND VELOCITY FOR RIGHT BANK:
1>36.3,7.51

ENTER NON-UNIFORM FLOW FACTOR:
1>1.5

ENTER RIGHT BANK SIDE SLOPE (H/V):
1>5,1

FOR RIGHT BANK

K2 = .00738
LOCAL BOUNDARY SHEAR STRESS TO = .62 PSF
K1 = .952
DESIGN SHEAR STRESS T = 2.27 PSF

DESIGN SHEAR STRESS EXCEEDS LOCAL BOUNDARY SHEAR STRESS
LESSER LAYER THICKNESS CAN BE TRIED

ADDITIONAL SHEAR COMPUTATIONS FOR SECTION: 102.000 ?
1>NO

MORE RIPRAP COMPUTATIONS AT SECTION: 102.000 ?
1>NO

FINAL RIPRAP DESIGN:

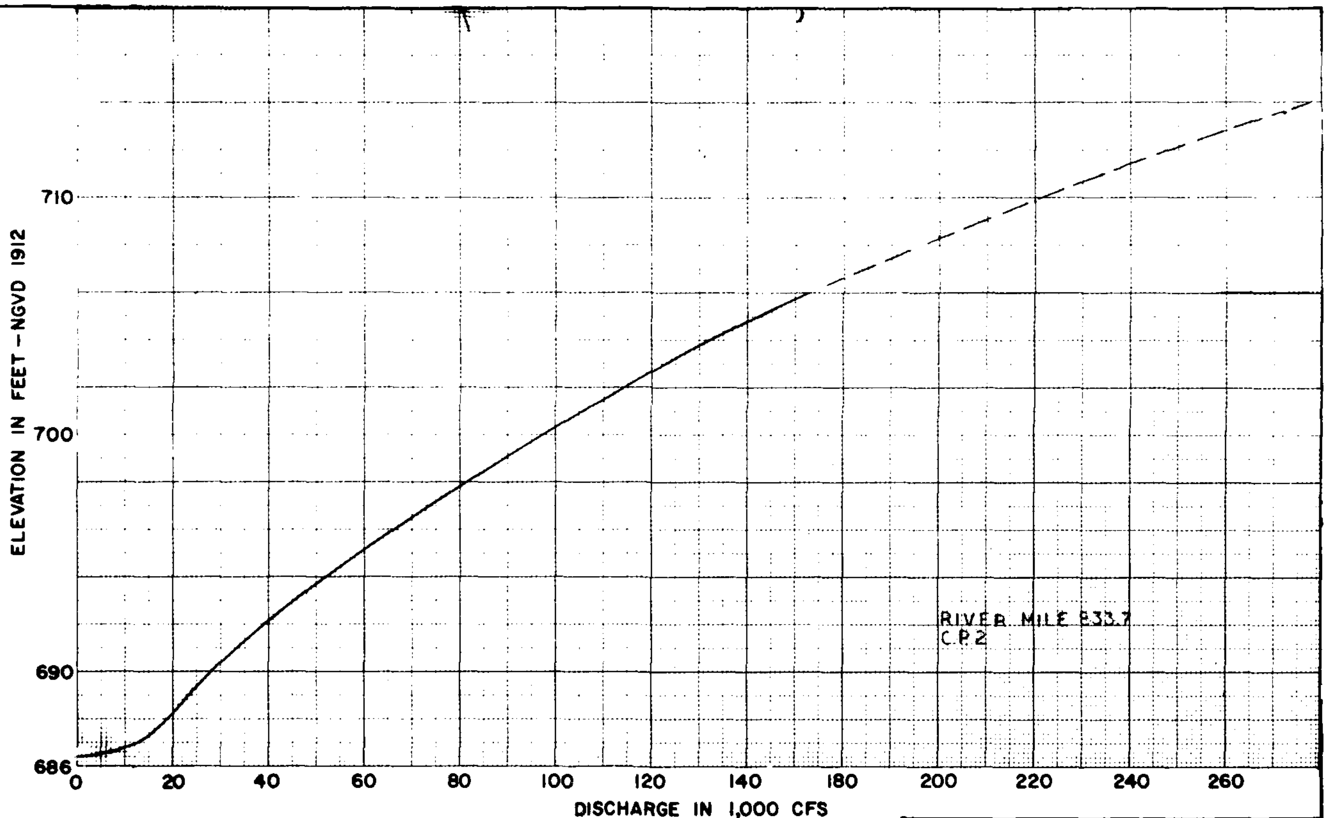
DATE OF COMPUTATION: 81/07/02. AT 05.24.00. HRS

CROSS SECTION NUMBER: 102.000

SPECIFIC WEIGHT OF STONE= 165 PCF

RIPRAP GRADATION
LAYER THICKNESS = 12 INCHES

PERCENT LIGHTER BY WEIGHT (SSD)	LIMITS OF STONE WEIGHT - LBS	
100	86	35
50	26	17
15	13	5

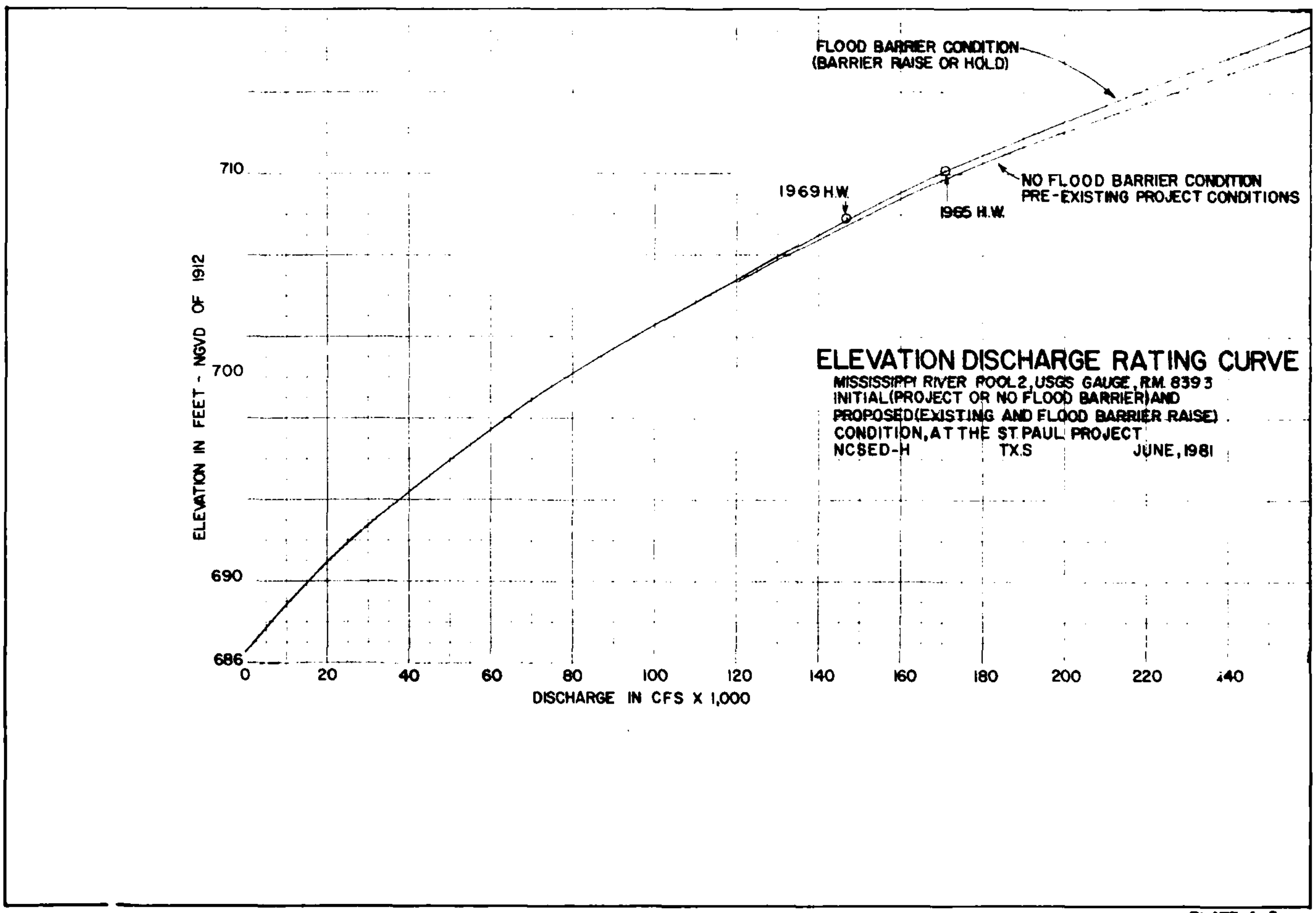


FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT

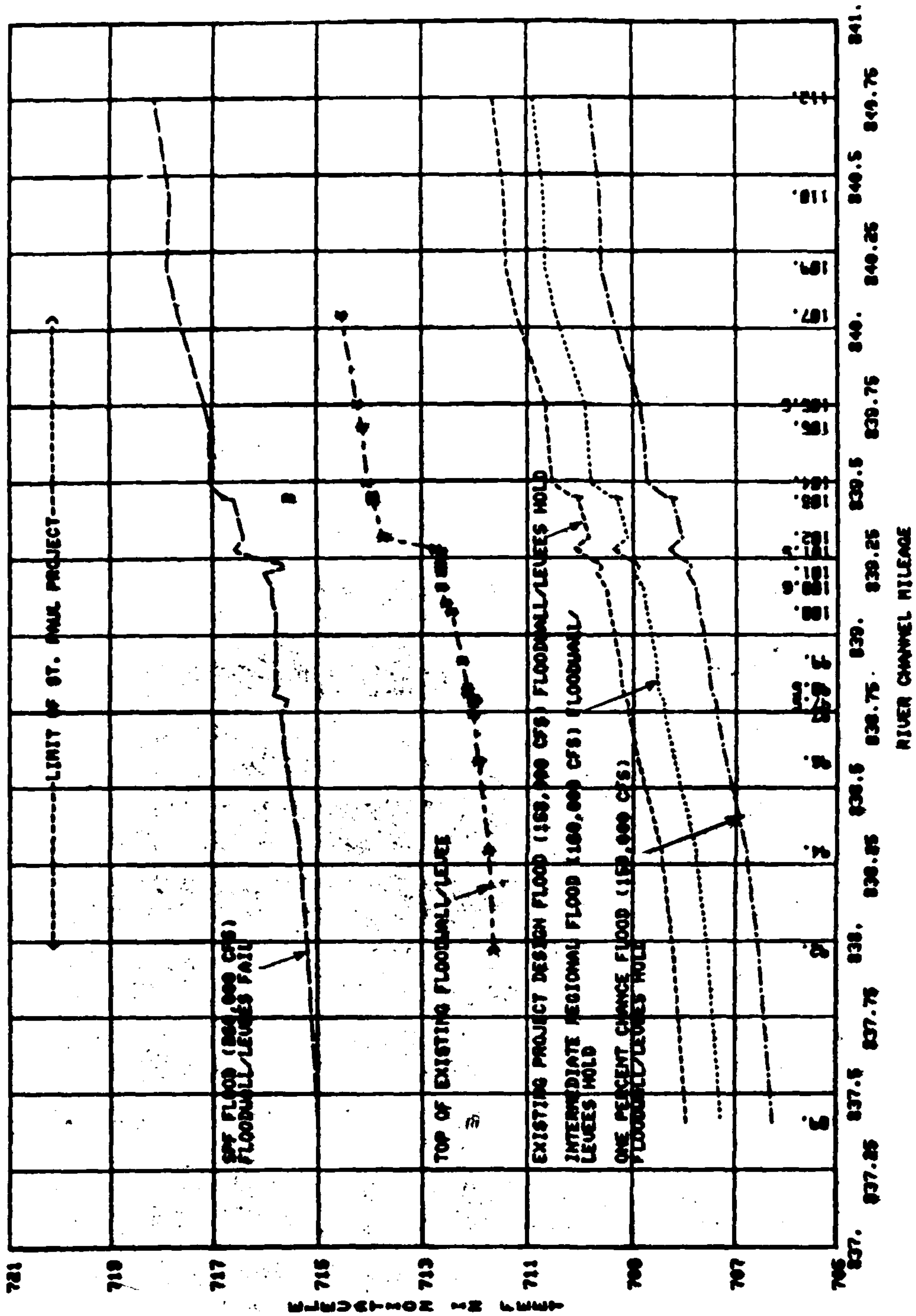
ELEVATION-DISCHARGE RATING CURVE

ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE NO. DATE:

PLATE 4-1



FLOOD BARRIER CONDITION
(BARRIER RAISE OR HOLD)
NO FLOOD BARRIER CONDITION
PRE-EXISTING PROJECT CONDITIONS
1969 H.W.
1965 H.W.
710
700
690
686
0
20
40
60
80
100
120
140
160
180
200
220
240
ELEVATION IN FEET - NGVD OF 1912
DISCHARGE IN CFS X 1,000
ELEVATION DISCHARGE RATING CURVE
MISSISSIPPI RIVER POOL 2, USGS GAUGE, R.M. 839.3
INITIAL (PROJECT OR NO FLOOD BARRIER) AND
PROPOSED (EXISTING AND FLOOD BARRIER RAISE)
CONDITION, AT THE ST. PAUL PROJECT
NCSED-H TXS JUNE, 1981

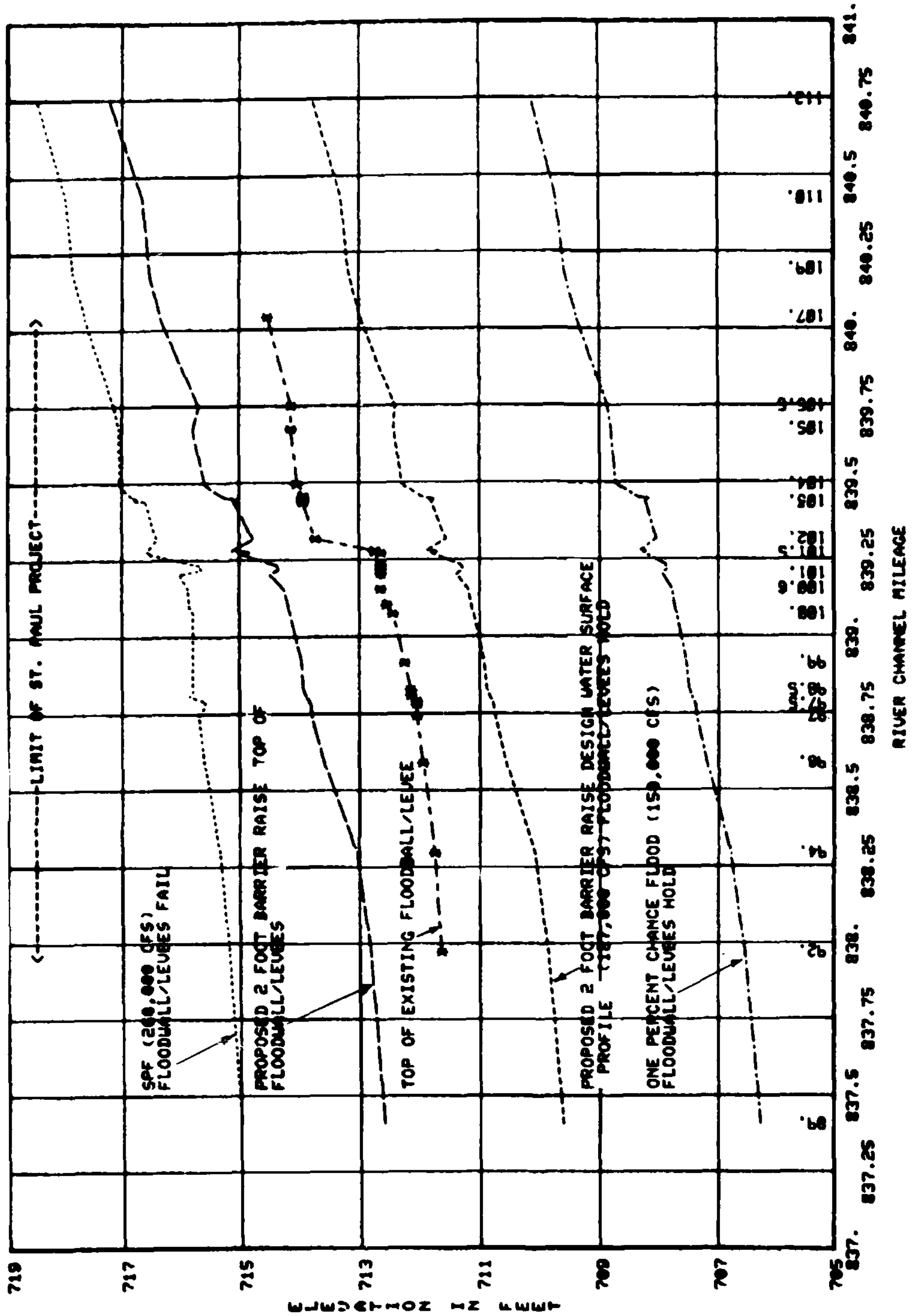


FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT

EXISTING CONDITION

ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE NO. DATE

PLATE 4-3

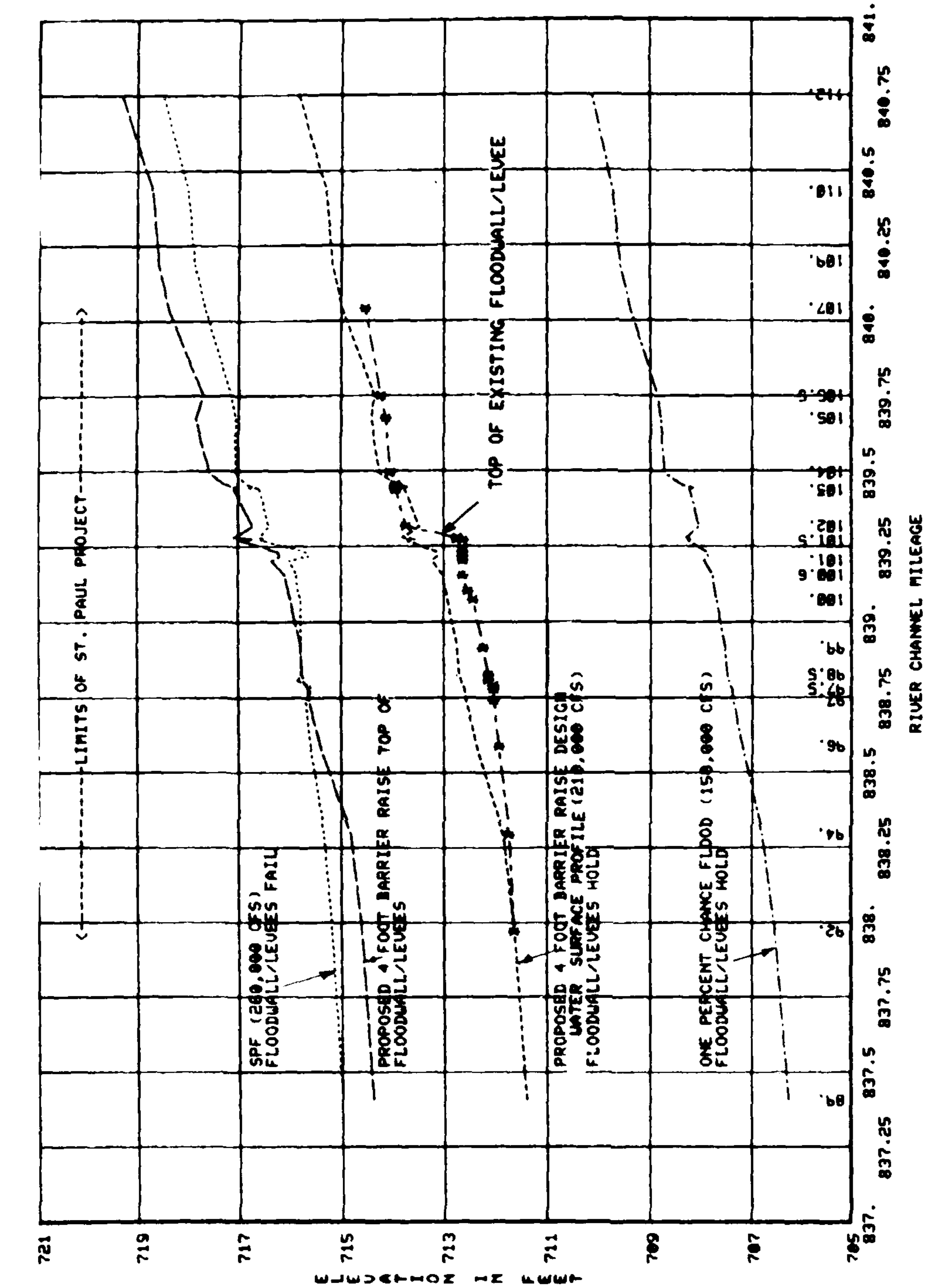


FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT

PROPOSED 2 FOOT BARRIER RAISE CONDITION

ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE NO. DATE

PLATE 4-4

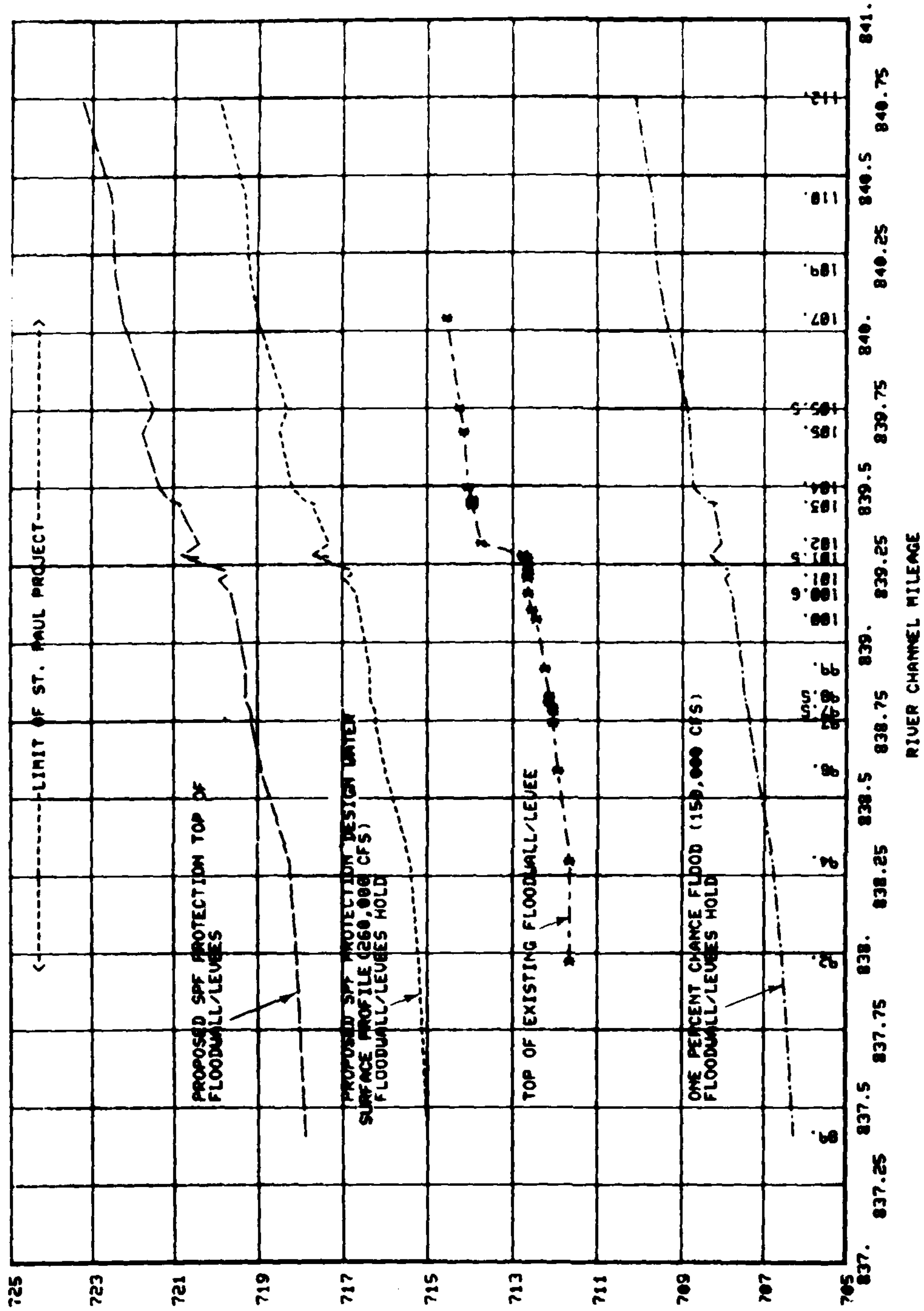


FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT

PROPOSED 4 FOOT BARRIER RAISE CONDITION

ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE NO. DATE

PLATE 4-5

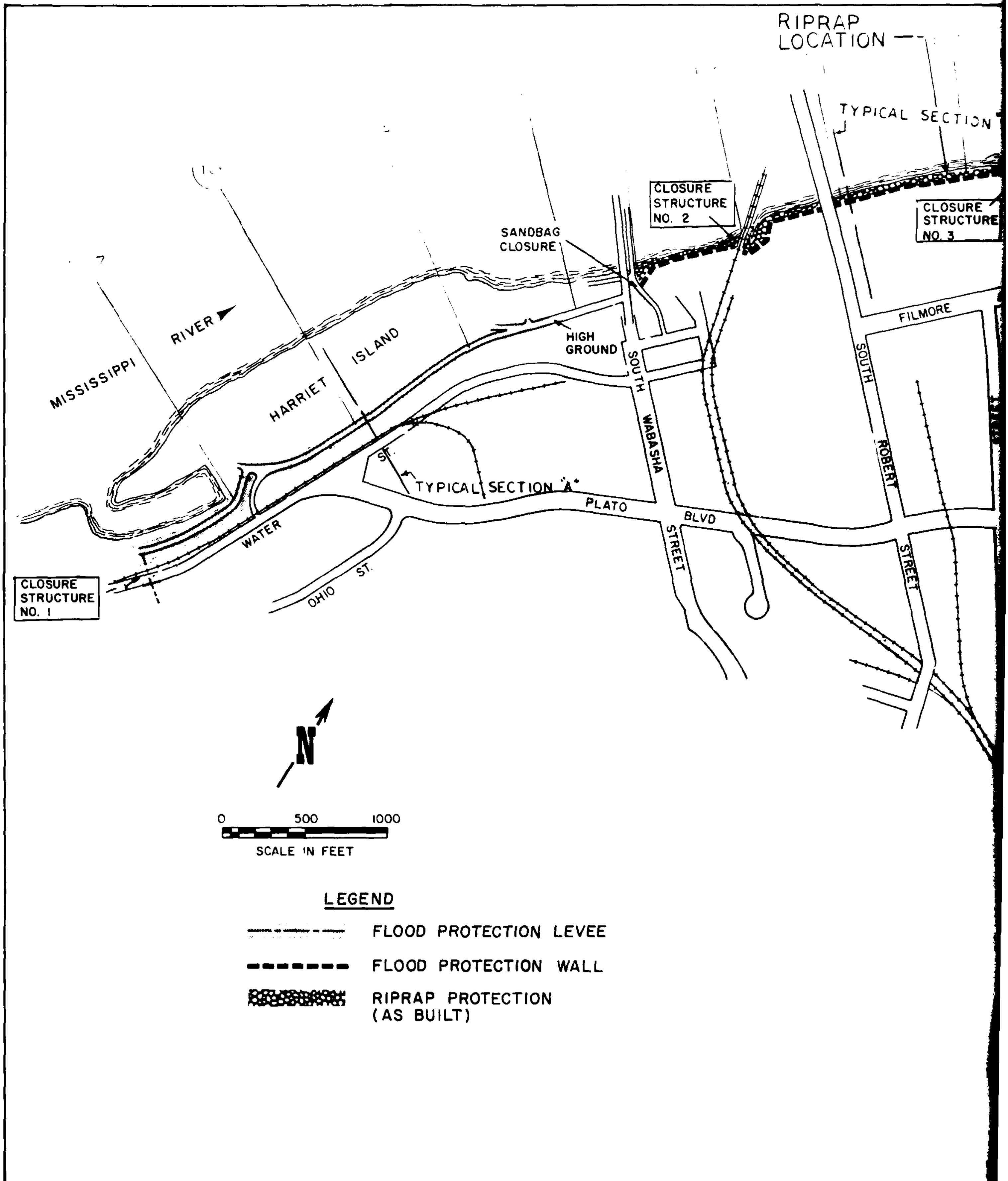


FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT

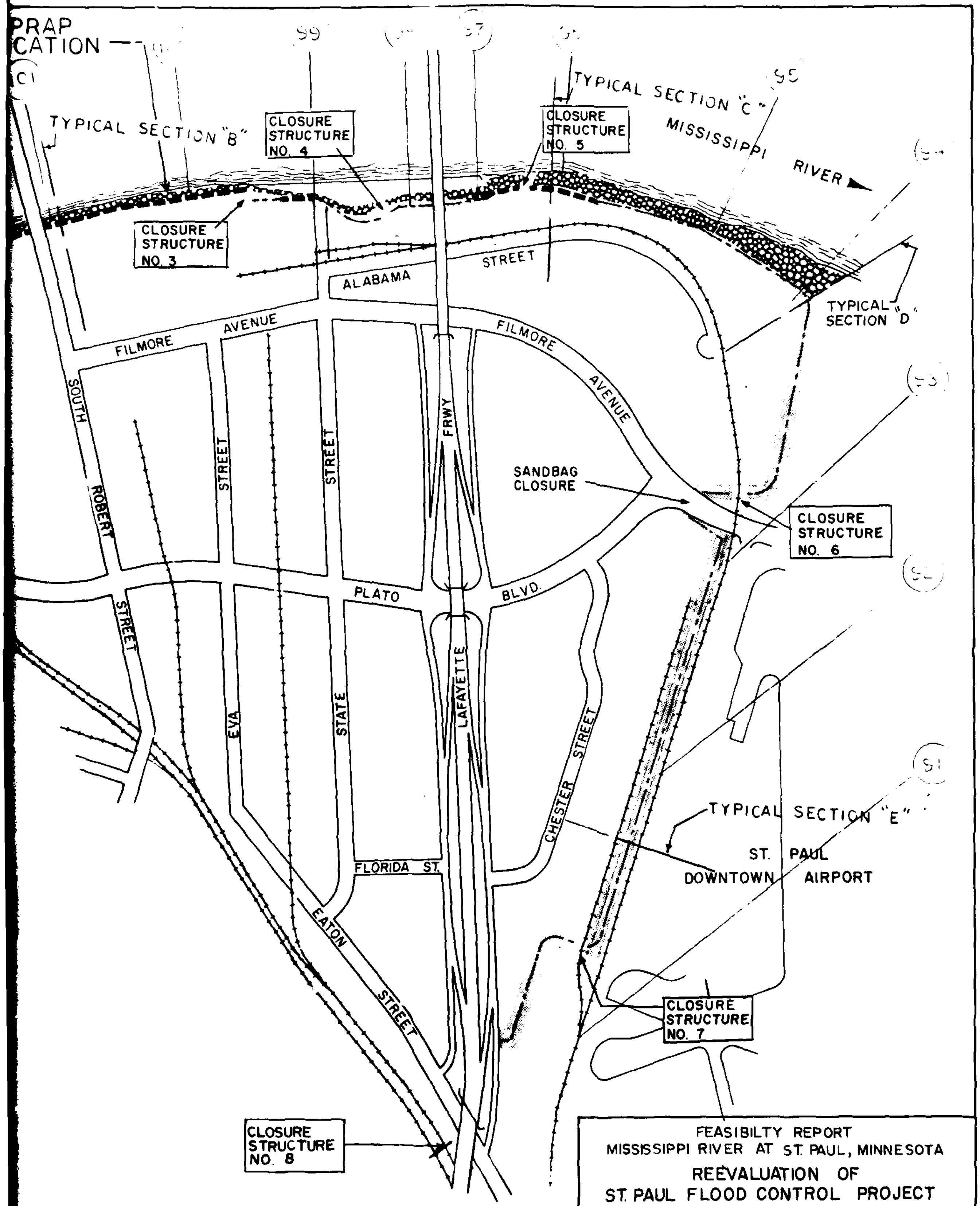
PROPOSED SPF PROTECTION

ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE NO. DATE

PLATE 4-6



RIPRAP LOCATION
TYPICAL SECTION
CLOSURE STRUCTURE NO. 2
CLOSURE STRUCTURE NO. 3
SANDBAG CLOSURE
HIGH GROUND
MISSISSIPPI RIVER
HARRIET ISLAND
FILMORE
SOUTH WABASHA STREET
SOUTH ROBERT STREET
TYPICAL SECTION 'A'
PLATO BLVD
WATER ST.
OHIO ST.
CLOSURE STRUCTURE NO. 1
N
0 500 1000
SCALE IN FEET
LEGEND
FLOOD PROTECTION LEVEE
FLOOD PROTECTION WALL
RIPRAP PROTECTION (AS BUILT)

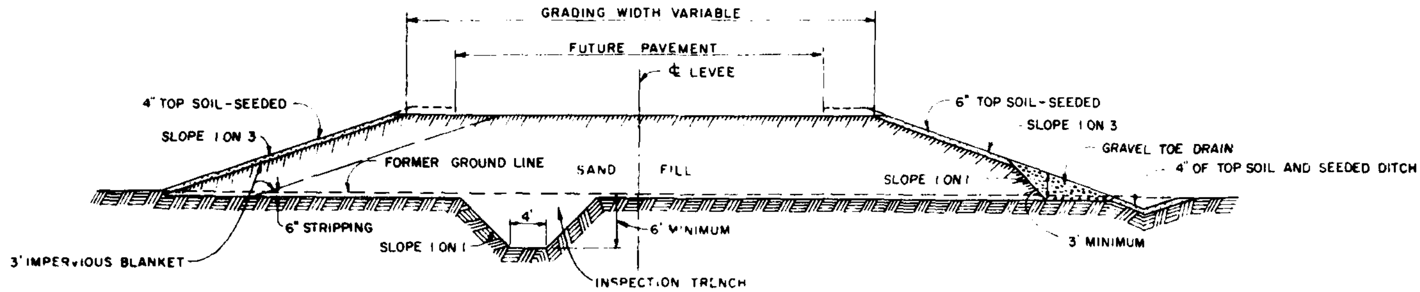


FEASIBILTY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT

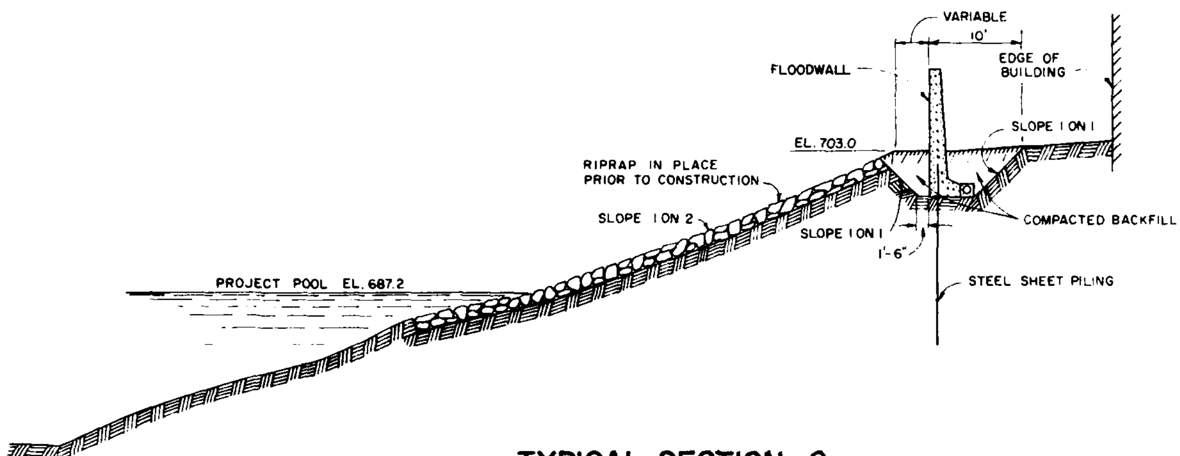
LOCATION OF RIPRAP AND CLOSURE STRUCTURES

ST. PAUL DISTRICT CORPS OF ENGINEERS
SEPTEMBER 1981

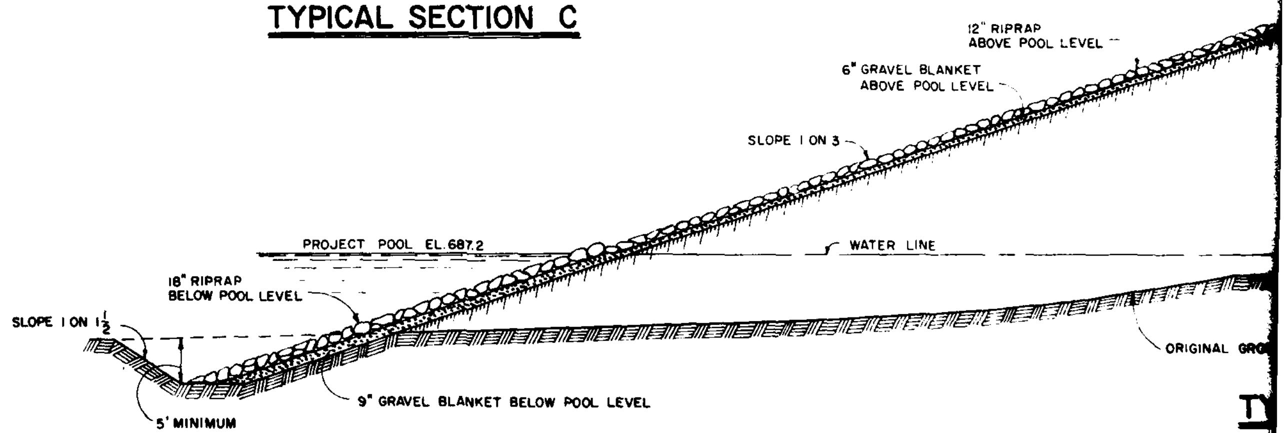
PLATE 4-7

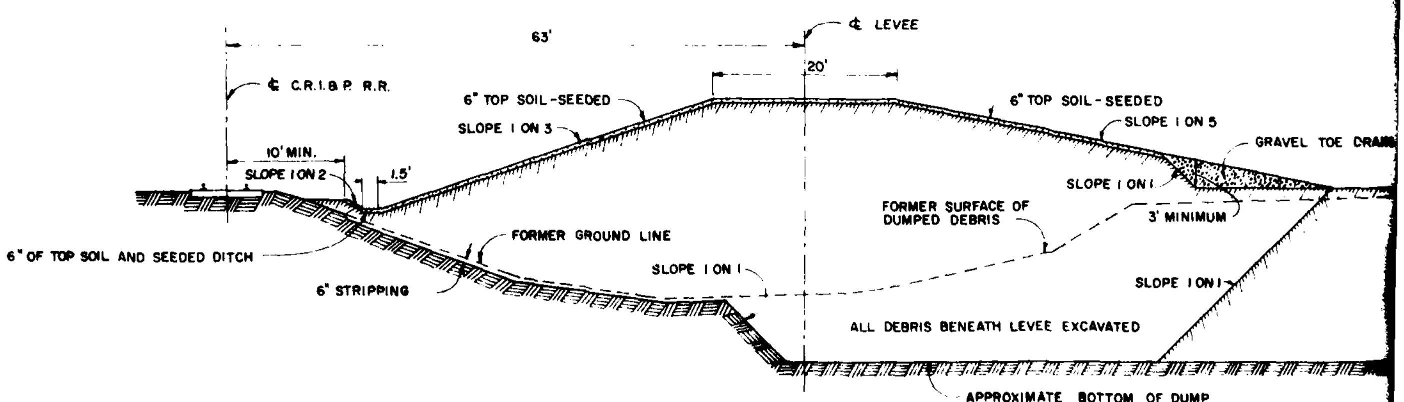


TYPICAL SECTION A



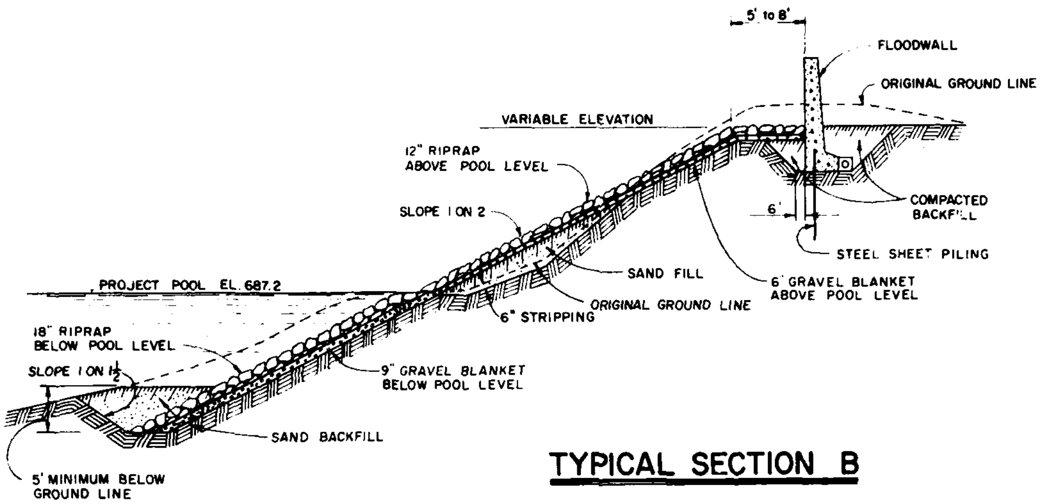
TYPICAL SECTION C



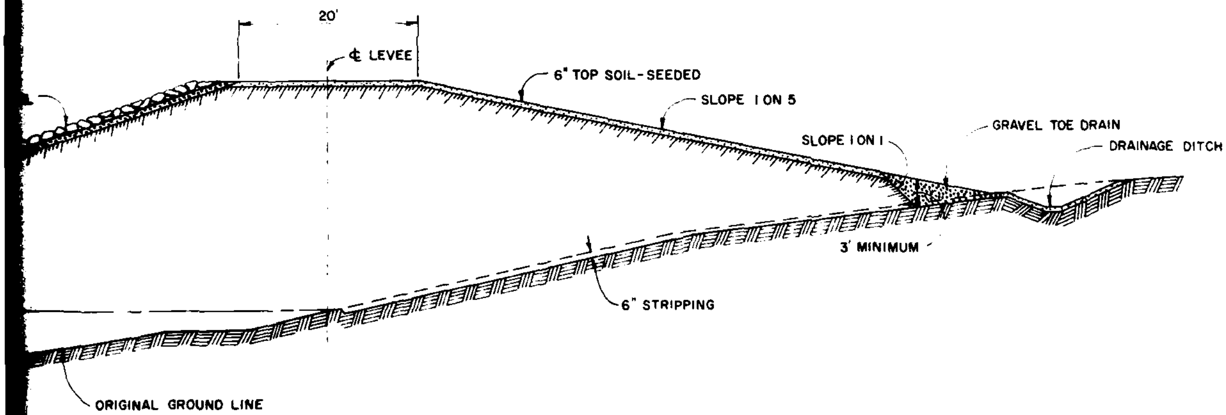


TYPICAL SECTION E

D SEEDED DITCH



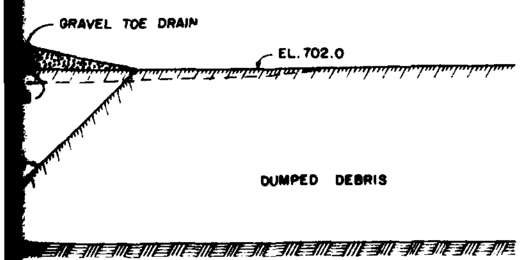
TYPICAL SECTION B



TYPICAL SECTION D

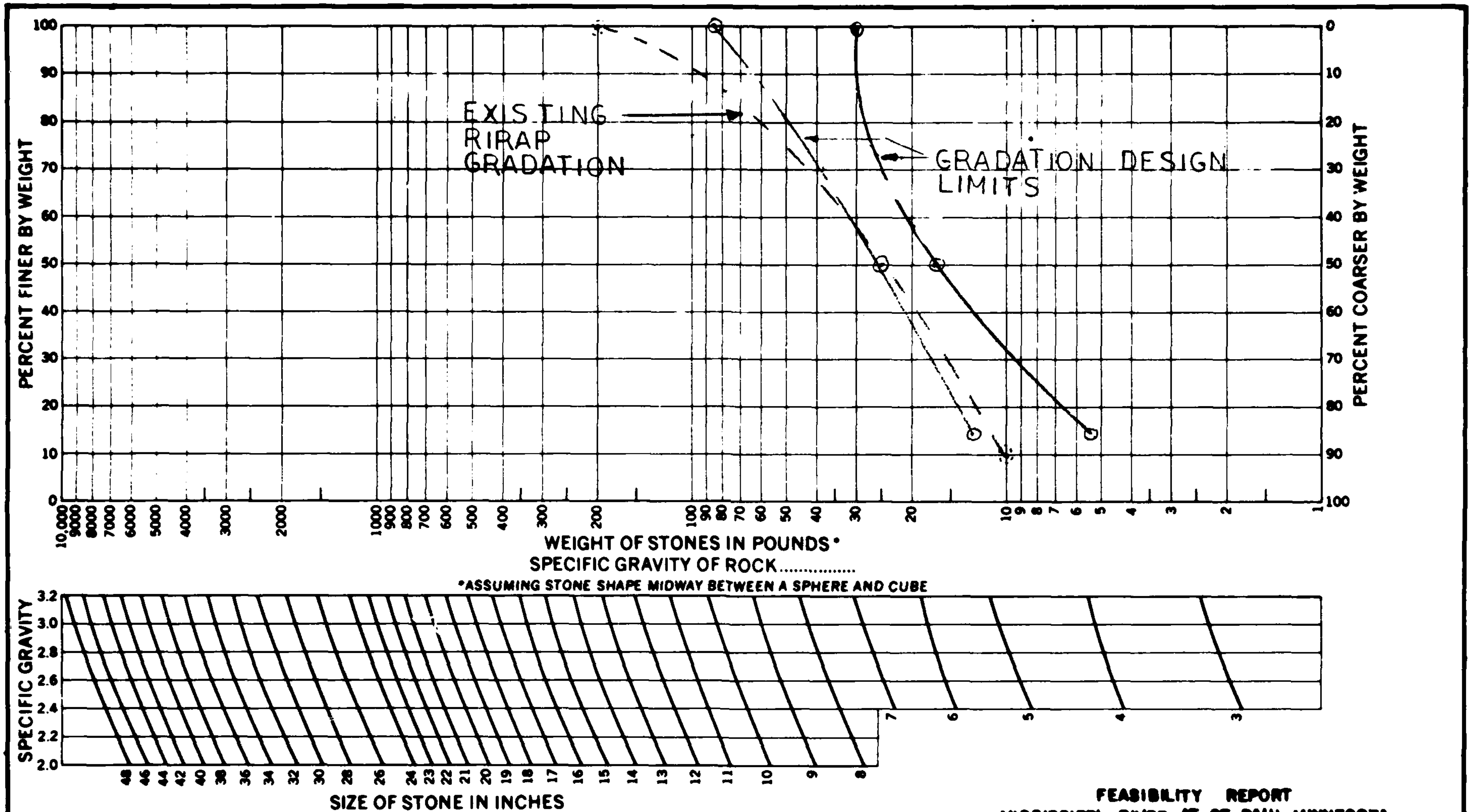
ELEVATIONS REFER TO M.S.L. (1912 ADJ.)

10 5 0 10 20
SCALE IN FEET



FEASIBILTY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST PAUL FLOOD CONTROL PROJECT
LEVEE AND FLOODWALL SECTIONS
ST PAUL DISTRICT CORPS OF ENGINEERS
SEPTEMBER 1981
PLATE 4-8

12

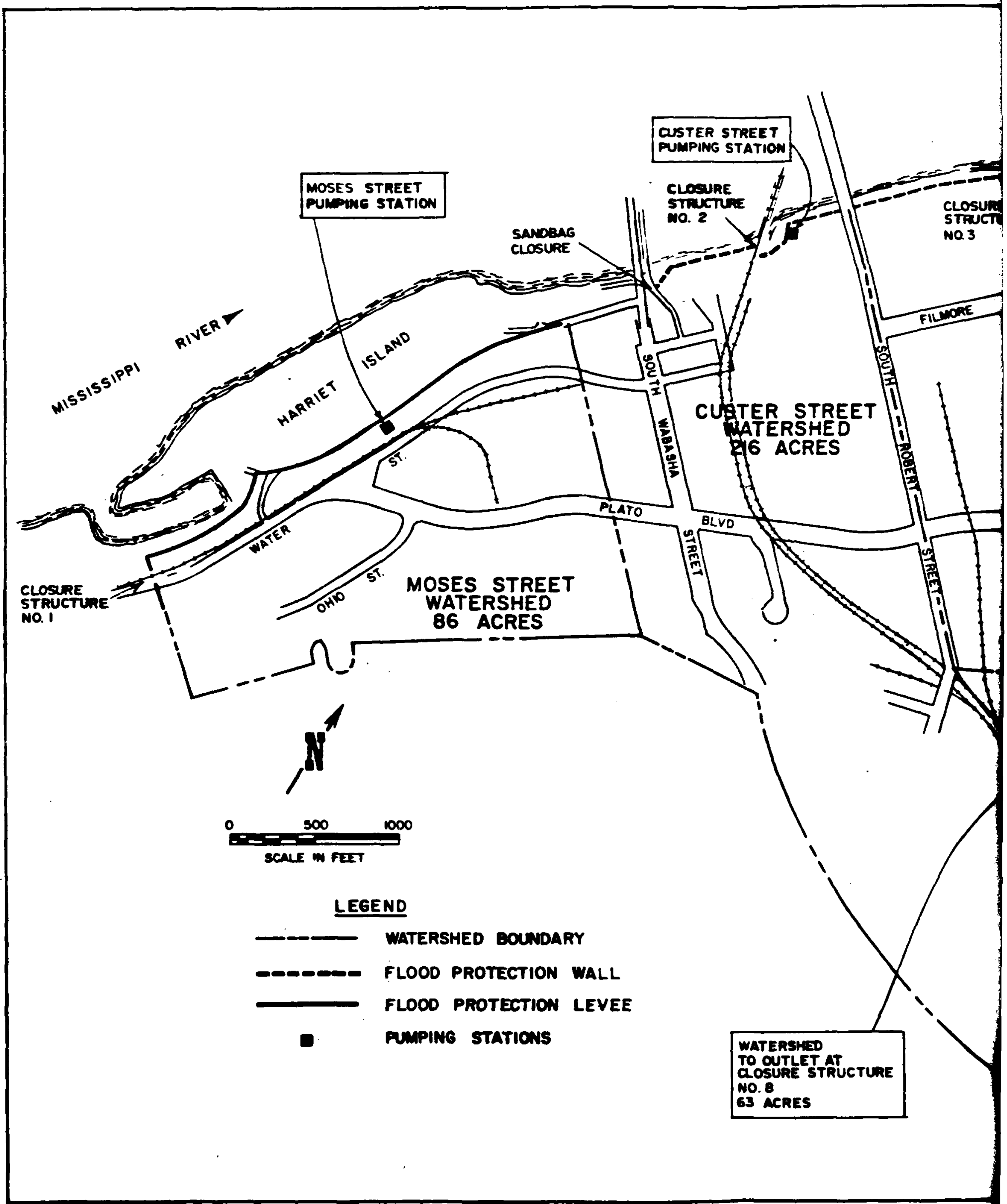


FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT

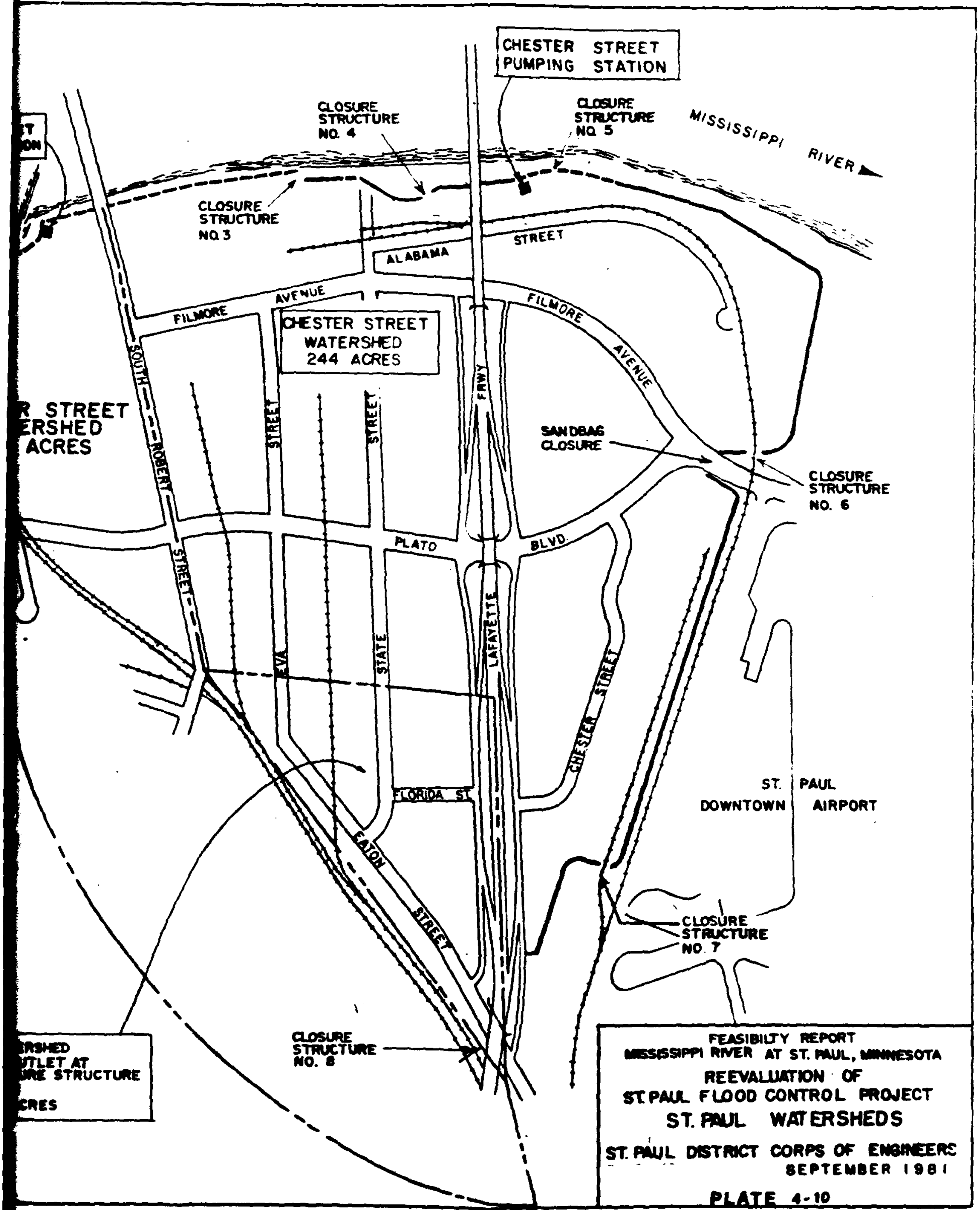
RIPRAP GRADATION

ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE NO. DATE

PLATE 4-9



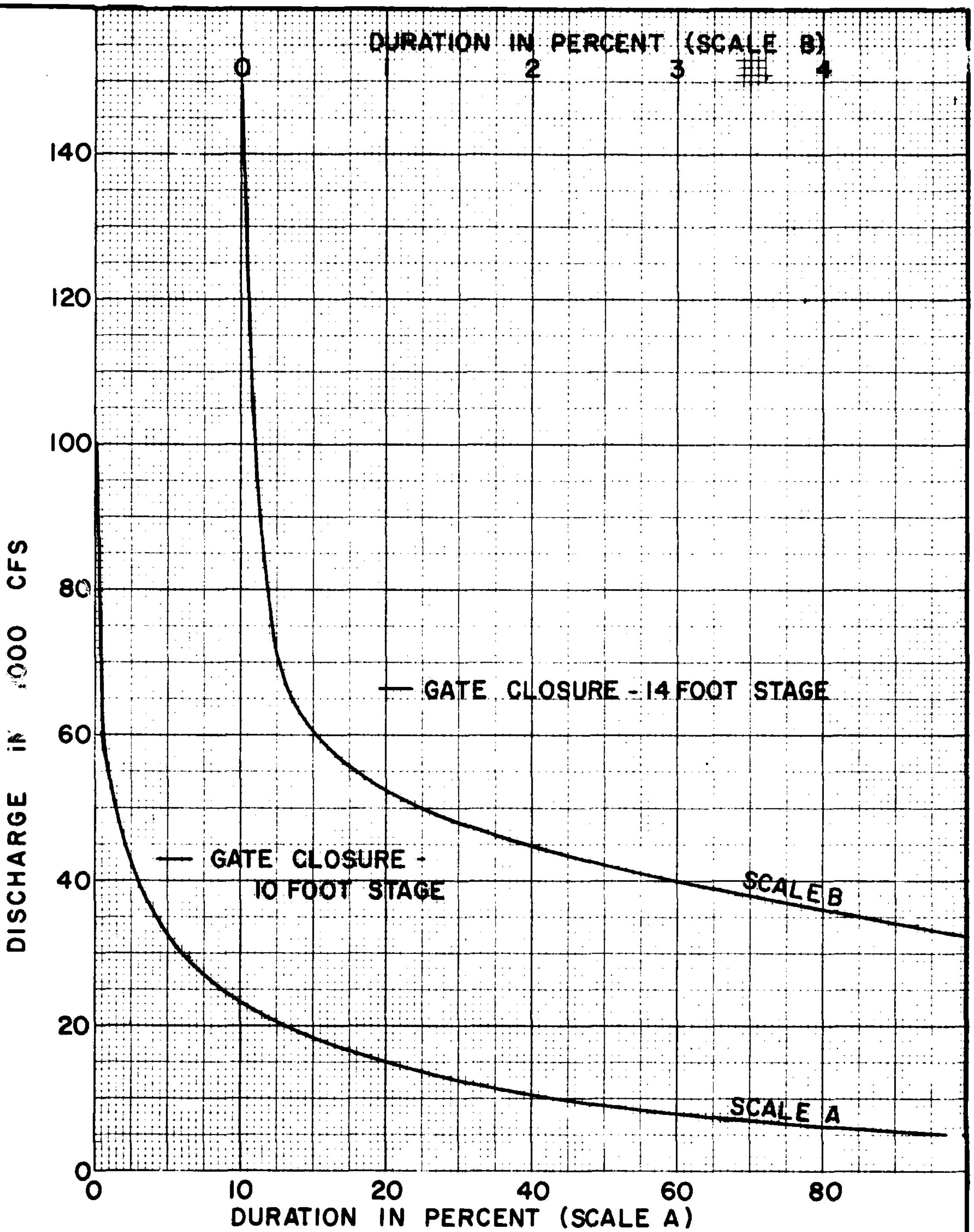
CUSTER STREET PUMPING STATION
MOSES STREET PUMPING STATION
CLOSURE STRUCTURE NO. 2
CLOSURE STRUCTURE NO. 3
SANDBAG CLOSURE
MISSISSIPPI RIVER
HARRIET ISLAND
FILMORE
SOUTH WABASHA STREET
SOUTH ROBERT STREET
CUSTER STREET WATERSHED 216 ACRES
ST.
WATER
PLATO BLVD
OHIO ST.
MOSES STREET WATERSHED 86 ACRES
CLOSURE STRUCTURE NO. 1
N
0 500 1000
SCALE IN FEET
LEGEND
WATERSHED BOUNDARY
FLOOD PROTECTION WALL
FLOOD PROTECTION LEVEE
PUMPING STATIONS
WATERSHED TO OUTLET AT CLOSURE STRUCTURE NO. 8 63 ACRES



FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT
ST. PAUL WATERSHEDS
ST. PAUL DISTRICT CORPS OF ENGINEERS
SEPTEMBER 1981

PLATE 4-10

2

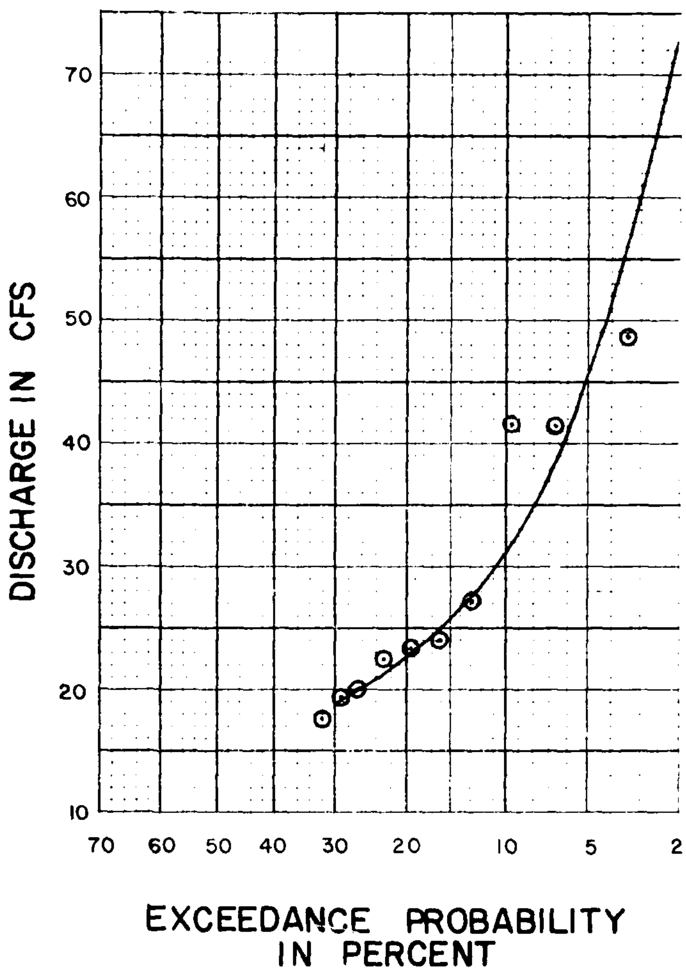


FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT

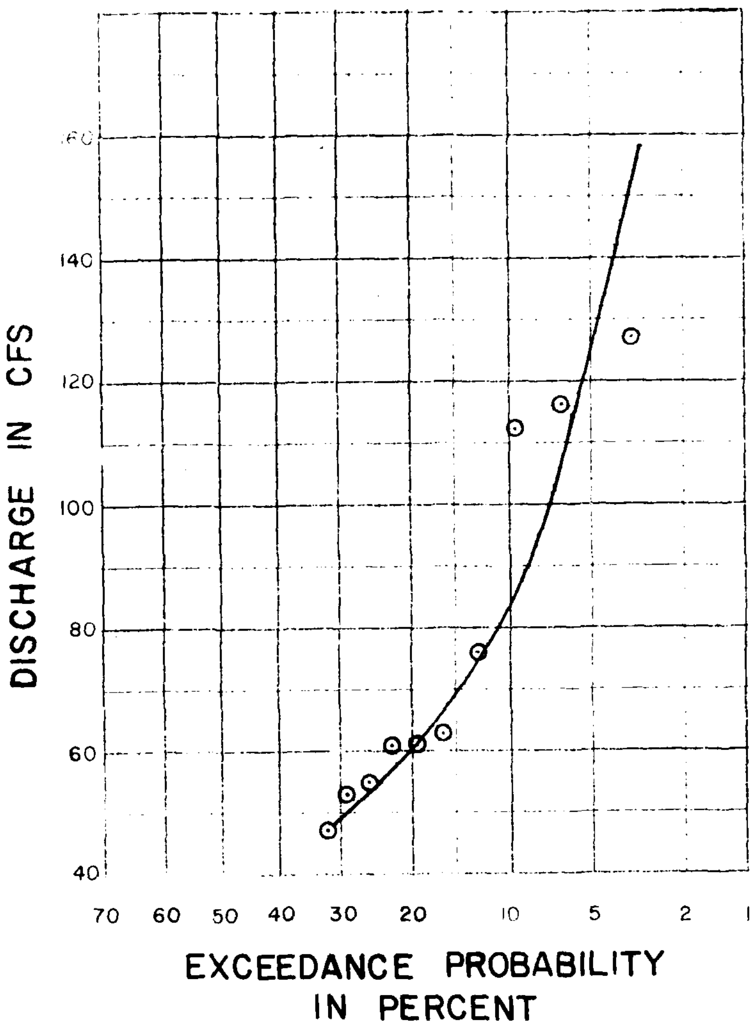
DISCHARGE-DURATION CURVES

ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE NO. DATE

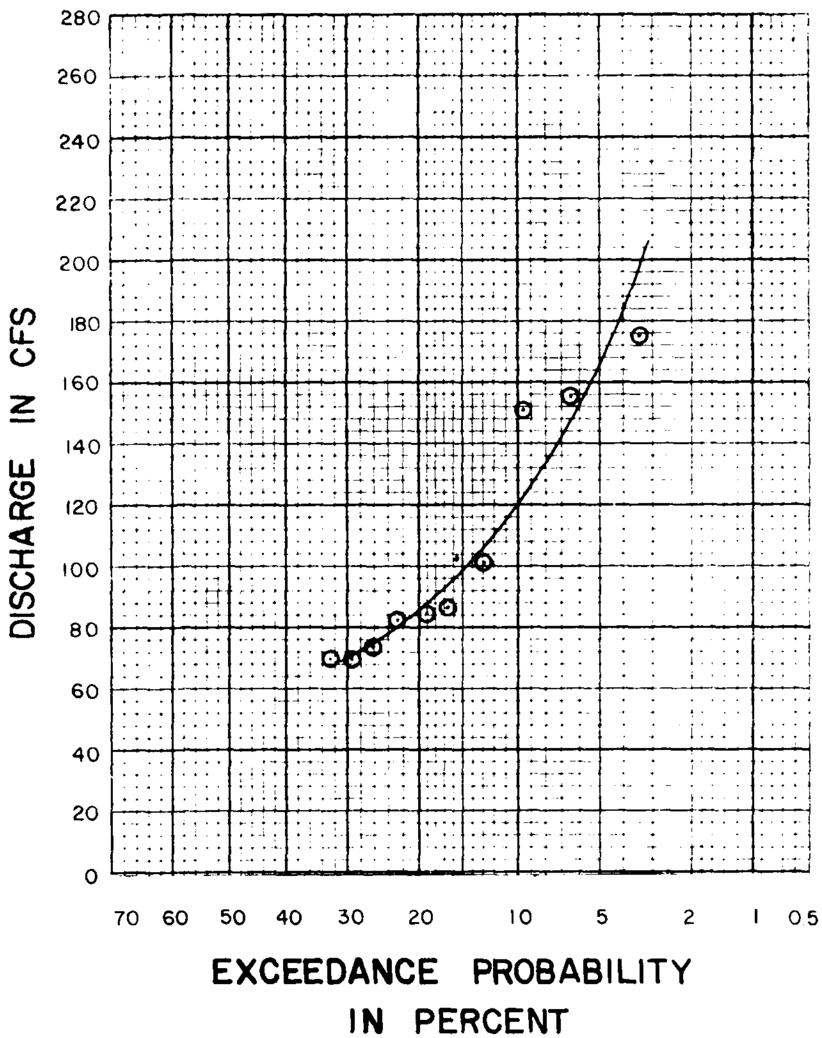
PLATE 4-11



FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT
DISCHARGE FREQUENCY CURVES
MOSES STREET WATERSHED
ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE NO. DATE

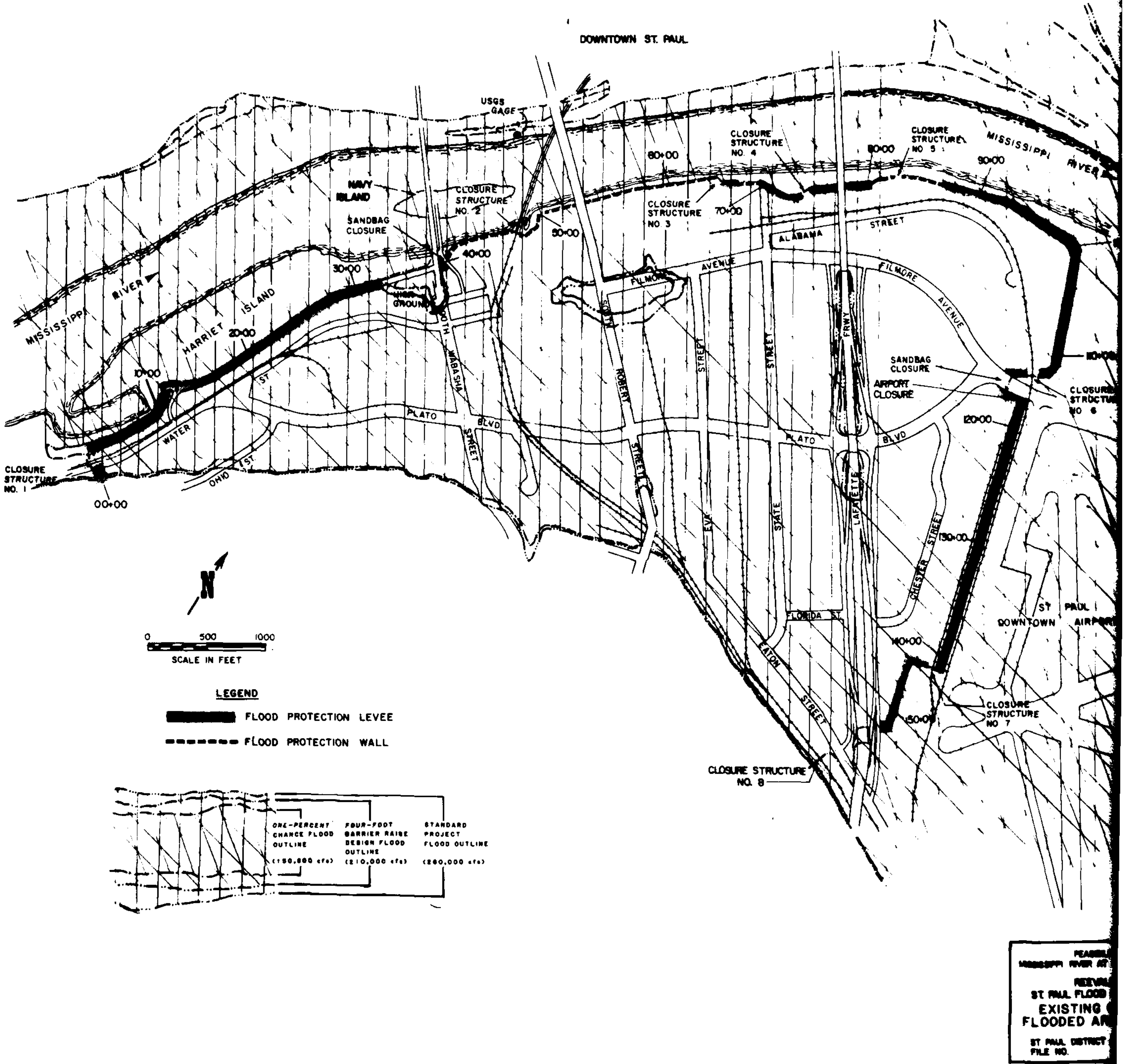


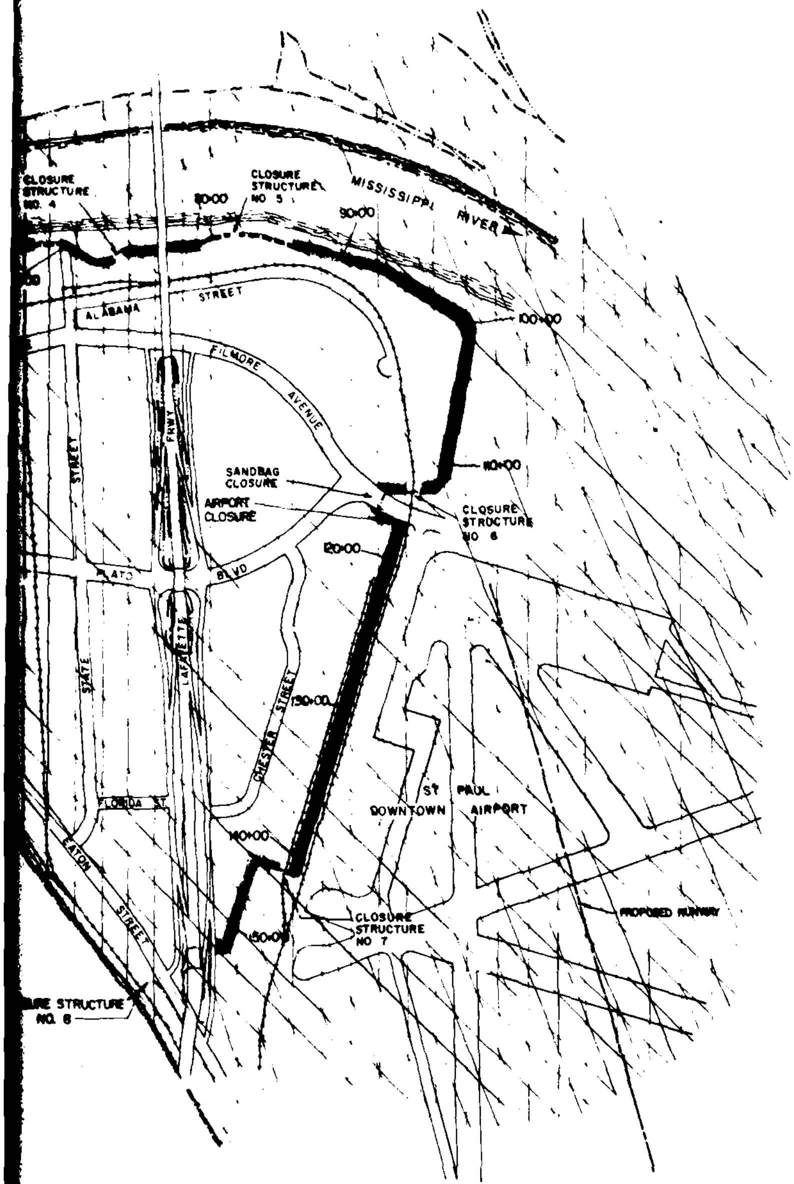
FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT
DISCHARGE FREQUENCY CURVES
CUSTER STREET WATERSHED
ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE NO. DATE



FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT
DISCHARGE FREQUENCY CURVES
CHESTER STREET WATERSHED
ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE NO. DATE

PLATE 4-14


DOWNTOWN ST. PAUL
USGS GAGE
MISSISSIPPI RIVER
NAVY ISLAND
CLOSURE STRUCTURE NO. 2
SANDBAG CLOSURE
HARRIET ISLAND
HIGH GROUND
CLOSURE STRUCTURE NO. 1
CLOSURE STRUCTURE NO. 3
CLOSURE STRUCTURE NO. 4
CLOSURE STRUCTURE NO. 5
CLOSURE STRUCTURE NO. 6
CLOSURE STRUCTURE NO. 7
CLOSURE STRUCTURE NO. 8
AIRPORT CLOSURE
00+00
10+00
20+00
30+00
40+00
50+00
60+00
70+00
80+00
90+00
120+00
130+00
140+00
150+00
WATER ST.
OHIO ST.
PLATO BLVD
WABASHA STREET
ROBERT STREET
FILMORE AVENUE
ALABAMA STREET
EVA STREET
STATE STREET
FRWY
LAFAYETTE
CHESTER STREET
FLORIDA ST.
EATON STREET
ST PAUL DOWNTOWN
N
0 500 1000
SCALE IN FEET
LEGEND
FLOOD PROTECTION LEVEE
FLOOD PROTECTION WALL
ONE-PERCENT CHANCE FLOOD OUTLINE (150,000 cfs)
FOUR-FOOT BARRIER RAISE DESIGN FLOOD OUTLINE (210,000 cfs)
STANDARD PROJECT FLOOD OUTLINE (260,000 cfs)
EXISTING
ST PAUL DISTRICT
FILE NO.

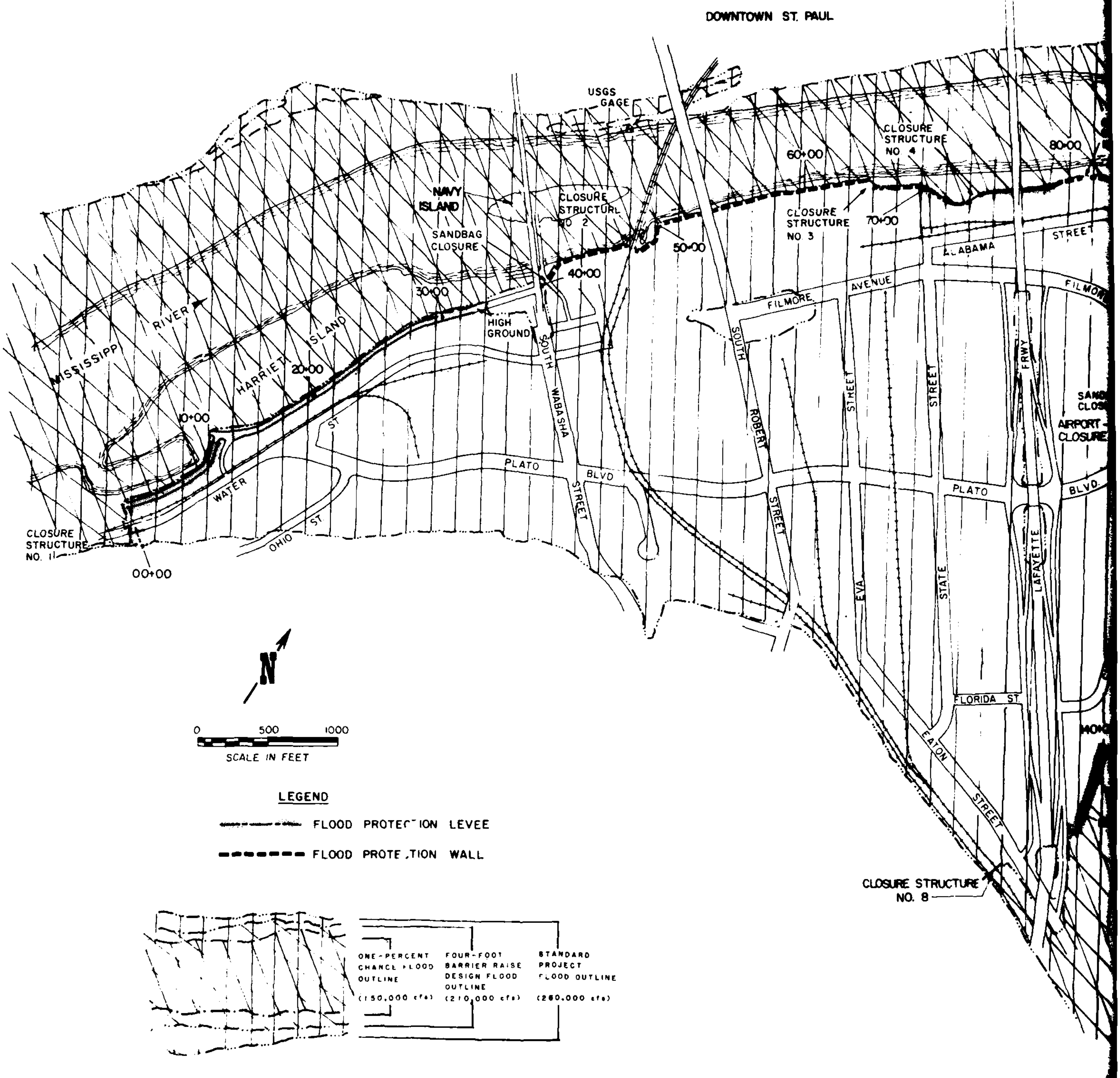


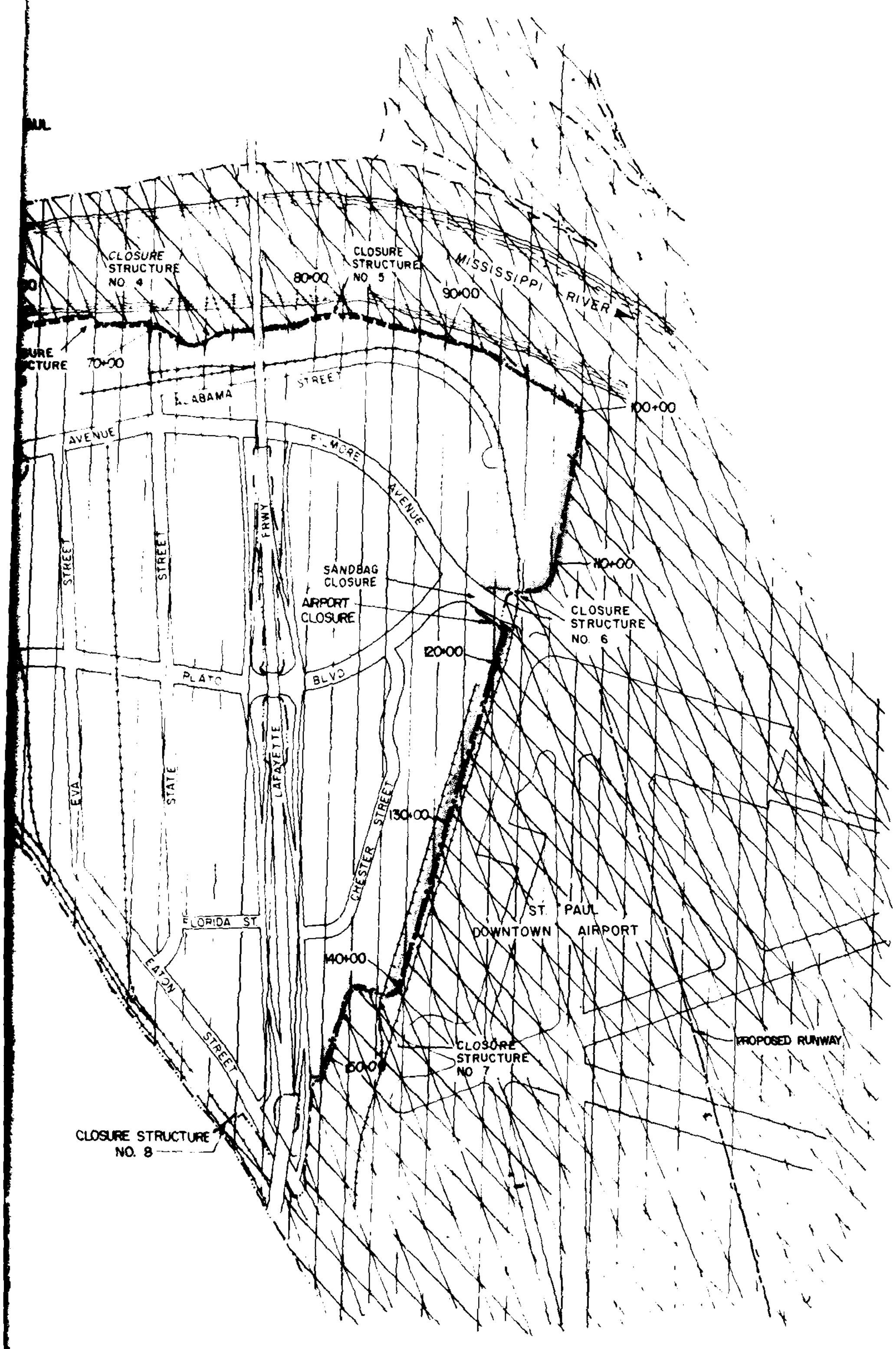
FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA

REEVALUATION OF
ST PAUL FLOOD CONTROL PROJECT
EXISTING CONDITIONS
FLOODED AREA OUTLINES

ST PAUL DISTRICT CORPS OF ENGINEERS
FILE NO. DATE

PLATE 4-15


DOWNTOWN ST. PAUL
USGS GAGE
NAVY ISLAND
SANDBAG CLOSURE
CLOSURE STRUCTURE NO 2
CLOSURE STRUCTURE NO. 4
CLOSURE STRUCTURE NO 3
CLOSURE STRUCTURE NO. 1
CLOSURE STRUCTURE NO. 8
AIRPORT CLOSURE
HIGH GROUND
MISSISSIPPI RIVER
HARRIET ISLAND
00+00
10+00
20+00
30+00
40+00
50+00
60+00
70+00
80+00
ALABAMA STREET
FILMORE AVENUE
SOUTH WABASHA STREET
SOUTH ROBERT STREET
EVA STREET
STATE STREET
LAFAYETTE FRWY
PLATO BLVD
WATER ST
OHIO ST
FLORIDA ST
EATON STREET
N
0 500 1000
SCALE IN FEET
LEGEND
FLOOD PROTECTION LEVEE
FLOOD PROTECTION WALL
ONE-PERCENT CHANCE FLOOD OUTLINE (150,000 cfs)
FOUR-FOOT BARRIER RAISE DESIGN FLOOD OUTLINE (210,000 cfs)
STANDARD PROJECT FLOOD OUTLINE (260,000 cfs)



FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA

REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT
PROPOSED CONDITIONS
4-FOOT BARRIER RAISE
FLOODED AREA OUTLINES

ST PAUL DISTRICT CORPS OF ENGINEERS
FILE NO. DATE

FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA

APPENDIX 5

REEVALUATION OF ST. PAUL FLOOD CONTROL PROJECT

ECONOMIC ANALYSIS

ST. PAUL DISTRICT, CORPS OF ENGINEERS
MARCH 1982

TABLE OF CONTENTS

TABLES

TABLES (continued)

TABLES (continued)

PLATES

PHYSICAL CONDITIONS

The study area consists of 448 acres along the right bank of the Mississippi River within the city of St. Paul, Minnesota, between river miles 838.3 and 840.3 above the mouth of the Ohio River. Through this reach the river flows generally northeast, and near the downstream end of the area it begins a wide sweeping bend to the south. The natural river valley varies from one-half to one mile in width; however, an existing local flood control levee and floodwall project constructed by the Corps of Engineers in 1964 confines high flows to roughly one-fourth to one-half mile, of which about 700 feet is the Mississippi River channel.

The existing project consists of a flood barrier about 3 miles long, extending from the upper end of Harriet Island to a point northwest of the St. Paul Downtown Airport (see plate 5-1). The barrier is primarily earth levee except for about one-half mile of noncontinuous floodwall along areas where concentrated industrial development limits space for levees. The project was designed with a freeboard of 2.8 feet to protect against a peak flow of 168,000 cfs (cubic feet per second). Included in the project are 13 closures, to permit use of roads and railroads during periods of normal water stages, and three pumping plants with about 7,000 feet of interceptor and stormwater sewers which were built to pump out seepage and rainwater from behind the barrier. The existing project is adequate and fully protects the study area to the 167-year flood level. Therefore, continued development is not restricted by State law or local ordinances.

Although the natural valley would, for the most part, be flooded by a 5-percent chance (20-year) flood, the project protects the study area access to the project design flood level. Wabasha Street, Robert Street, and the Lafayette Freeway provide access from the study area to the bluffs on either side of the river. In addition, Ohio Street exits from the study area to the south. With temporary measures, access can be maintained (but without certainty) within the project freeboard range.

Loss of life potential is considered minimal for floods in excess of project design because of the slow rising nature of the Mississippi River in this reach, which allows for adequate warning, and because of the availability of emergency evacuation routes.

ECONOMIC BASE

The protection of the Riverview Industrial Area of St. Paul by the Corps of Engineers in 1964 helped bring about a major redevelopment in area land use. Through the auspices of the St. Paul Port Authority, the city successfully relocated what was mostly low income, poor quality, floodprone residential and commercial structures from this floodplain area. Remaining businesses and industries became the core for the new industrial area.

Location and transportation availability make this one of the most advantageous sites in the Twin Cities Standard Metropolitan Statistical Area (SMSA). The Industrial Area is immediately across from the downtown business center of St. Paul as well as the State and County Offices and as such has all normal city services in place. The Holman Field regional airport, adjacent to the Industrial Park and in the floodplain, is not protected by the Corps project. Heavy rail spurs and trunk lines of large, economically-healthy railroads are available. Likewise, direct access to four-lane divided highways and the interstate system is just blocks away. Finally, river navigation is readily available if required.

The Twin Cities SMSA had a 1980 population of 2,108,950[1] people. The 9th Federal Reserve District serving all or part of six States is located in Minneapolis. Hundreds of large and medium size firms and thousands of smaller businesses have either home offices or regional offices in this SMSA.

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(1) Preliminary 1980 data.

Total employment in the industrial area fluctuates, but averages between 5,500 and 6,000. Because of the variety of type and size of firms, meaningful combined totals for sales and/or revenues cannot be provided. However, total assessed valuation of properties exceeds $100 milion. The total value of inventories for products and other capital goods and contents of buildings is in excess of $247 million.

LAND USE DEVELOPMENT

The present 1981 land use condition shown on plate 5-1 has evolved since 1964. About 89 acres of a total 448 acres were left in place as remaining development after removal of redevelopment structure.(1) Between 1964 and 1976 about 115 vacant project acres were developed or about 9.6 acres per year.

This period of time saw the removal of old properties, construction of the new local service road and city service systems, and most significantly the building of State Trunk Highway 3 (Lafayette Freeway) through the industrial park. The pace of development has increased dramatically since completion of Highway 3. Between 1976 and 1979 approximately 19 acres per year were developed. Remaining developable acres in 1979 totaled approximately 67 acres, down from 111 available acres in 1976. The development rate for 1979-1981 declined to about 9 acres per year because of the severity of the current economic recession. Of the remaining acres, 17 acres are limited development parcels due to airport operations at Holman Field. Little development is projected for these areas.

The remaining parcels represent a generally even mix of small, under 2 acre sites and larger sites in the 2- to 8.8-acre range. All of the sites are now adjacent to one or more of the existing structures. As of March 1982 sales,

1/ All acres are net acres; net acres are defined as development parcels exclusive of public roads and railroads.

construction and planned construction have been identified for 34 acres or 68 percent of the developable land. Interviews with the St. Paul Port Authority and private interests verified that all developable land will be developed by 1986.

EXISTING DEVELOPMENT CONDITIONS

The current occupants of the Riverview Industrial Area consist of 134 building or economic units. Almost half are involved primarily in light manufacturing and services. The remainder include warehousing, wholesale trade, heavy industry and office space, and transportation.

Distribution of industries and Land Use in the project area

Item	Number of units	Percentage	Acres of Land	Percentage of total acres
Warehouse	21	15.7	19	4.2
Light manufacturing	35	26.1	96	21.4
Heavy industry	14	10.4	87	19.4
Services	30	22.4	39	8.7
Wholesale	23	17.2	21	4.7
Office space	8	6.0	16	3.6
Transportation	3	2.2	21	4.7
Parkland	-	-	6	1.3
Streets and Highways	-	-	63	14.1
Vacant	-	-	67	15.0
All other	-	-	13	2.9
Total	13[illegible]	100.0	448	100.0

The relative sizes of these economic units vary in the extreme. A dozen or so firms employ hundreds of employees, serving National and/or international markets through the production, distribution, services or manufacturing facilities based in this industrial area. Other medium size firms are either regionally oriented, represent small business markets, or are the regional facilities of a larger firm with other regional locations and productive sites elsewhere. The majority of the economic units,

however, consist of smaller businesses with total operations located in the industrial park. Thus interruption of businesses will have a variety of impacts depending on the economic unit. These impacts were fully considered during the evaluation of damages.

Relocation of Brown and Bigelow, one of the Nation's largest specialty advertisers, has helped the Industrial Park retain businesses and has encouraged and aided redevelopment. Other new arrivals into the industrial park, such as the Department of Agriculture building, Group Health, Inc.'s business and service center, American Red Cross building, and a new State Bank, were attracted by a central location and complementarity and proximity to clients or offices important to their own businesses. Other businesses have grown dramatically over the years and expanded both internally within existing structures and by additions to their buildings and properties. Many of these businesses have allowed for this growth on previously vacant acres they control or exercised first option on vacant acreage adjacent to their operations.

Turnover rates in the park appear typical for the group of businesses represented. Tenants that move are generally replaced by others that are growing and expanding and hope to continue growth in improved facilties provided in the industrial park. Normal attrition is present in the form of business failures or closures and consolidation of operations elsewhere. New replacement tenants cannot be expected necessarily to be equal in size or type of operation on a one-to-one exchange basis. However, it is reasonable to expect that on the average new operations of businesses will be equivalent in total in investment and susceptability to interruption by a catastrophic flood. Clearly, the high degree of protection provided by the existing project has allowed longer term investment decisions to be made without immediate concern for the remaining flood threat.

FLOOD DAMAGES

METHODOLOGY

Basic to the existing damage analysis for this study is the assumption that a damage interview of a commercial or industrial unit can adequately estimate the full range of damages in monetary terms for possible ranges of water surface elevations. One hundred percent of the total developmental unit population was interviewed. Details of damage subcategories will be discussed, described, and displayed in summary fashion for these interviews. Implicit in the proper estimation of damage is an understanding of the nature of the business and factors which are critical to the firm. Only then can the full impact of a flood be financially measured. The cooperation and input of the entrepreneur are absolutely essential in the application of this damage assessment process.

Similarly, the projection of future developmental conditions is highly dependant upon the knowledge and growth plans of these same entrepreneurs. During the personal interview for existing damages, a series of questions was asked to identify how the existing conditions damage source will change in the future. This study-of-the-firms approach takes advantage of the corporate planning process. In general, the process identifies the capital improvements scheduled and the necessary improvements or damages which must be planned for in advance to accommodate growth. While economic cycles and special situations may affect the timing, an initial 5-year planning horizon can usually be made available through discussion interviews.

The biggest limitation of the study-of-the firm method is the short planning periods used by firms. Confidence levels decrease quickly for most businesses between 1 and 5 years. By the 10th year, only firms with long range planning capabilities can contribute much information that is relevant to damage projections. Investment decisions are generally implemented a year or two at a time through the firm's budgeting process. Thus some changes are easily identified as orders or requirements already on the books. These planned actions are often part of a larger 5-year or contingency plan; i.e., if trends

Confidence levels decrease quickly for most businesses between 1 and 5 years. By the tenth year only firms with long range planning capabilities can contribute much information that is relevant to damage projections. Investment decisions are generally implemented a year or two at a time through the firm's budgeting process. Thus some changes are easily identified as orders or requirements already on the books. These planned actions are often part of a larger 5-year or contingency plan; i.e., if trends continue, the firm will continue the plan, otherwise the firm will take alternative plan X, subject to reevaluation at any point along the way.

Finally, transference of damages by area has also been applied in appropriate situations to predict future conditions. This methodology has been useful in situations related to estimating induced residual damages. Essentially, damages are synthesized by analytically placing existing firms in vacant areas and at flood risk for the study area and then measuring the damages. The selected firms are considered proxies for the actual firms that will be making future locational decisions represented in the land use projection. Damage densities and the characteristics of these new firms are assumed to be similar to those of the existing stock of firms in the study area. This, in essence, is an extension of the assumption that damage persistence will not change appreciably with turnover of existing businesses over time. The method is thus dependent upon a land use projection, not a damage projection. Damage follows development. This is a critical distinction since the Water Resource Guidelines are clearly against unwarranted speculation concerning future commercial-industrial damages.

General

During the course of the study, every existing-damage unit was surveyed for potential flood damages from large and rare floods. Initial interviews of all businesses in the industrial area were conducted in 1977. An interim survey was conducted 6 months after the original survey to collect damage information on new businesses and expansions. Additional interim surveys were conducted in 1979.

The damage form, plate 5-2, was used to compile data on flood damages. Three elevations in relation to the Robert Street river gage were used to compile damages for each firm: the existing barrier overtop level, the barrier overtop plus 4 feet, and the barrier overtop plus 6 feet. The slope of the river profile and increased or reduced elevations with respect to the Robert Street gage were taken into account; i.e., the elevation at the three levels is slightly lower at the downstream end of the project and damages for those levels were calculated at the lower elevation values.

Because of the dynamic nature of the area, a new survey was conducted in July 1981 to identify growth to the larger damage units surveyed previously and to get information on new development since the previous survey. From earlier surveys, 13 businesses were identified as having 88 percent of potential damages; these were resurveyed. Five other businesses which were new since 1979 or had substantial additions constituted the balance of the 1981 interviews.

Early in the 1981 survey, it became obvious that the businesses that were being interviewed had been growing and would continue to grow. New questions were added to the standard interview to take into account these proposed conditions. The new questions also asked about the likelihood and cost of evacuation should flood stages be predicted at the freeboard level and at barrier overtop. The additional questions are listed on plate 5-3.

The following tables show the results of the surveys for each damage category for the following groups: damages to major damage units interviewed in 1981, damages to new units and additions interviewed in 1981, and damages to units not interviewed in 1981 updated to 1981 conditions based on growth experienced by the larger units.

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The first table shows two sets of wage and profit losses. The first set of wage and profit losses, shown in parentheses, reflects total losses reported by 13 major firms if the flood event specified occurred. The second set of losses shown are those judged to have a high probability of being losses to the national economy. The second set of losses was therefore used in determining damages which could qualify for NED benefits with a barrier raise. The second and third tables reflect wage and profit losses which would be experienced if the flood event specified occurred. However, losses to these firms were not judged to have a high probability of being losses to the national economy. Therefore, such losses were not used for NED benefit calculations. Interview data on wage and profit losses for individual firms as well as information provided on their respective markets were deemed confidential and are therefore not displayed.

Damages by category
for 13 major damage firms interviewed in 1981
Riverview Industrial Area
(1981 prices and conditions)

Damage category	Damages at barrier overtop (1,000's)	Damages at barrier overtop plus 4 ft. (1,000's)	Damages at barrier overtop plus 6 ft. (1,000's)
Transportation	10	10	10
Damage to buildings	6,036	6,191	6,347
Damage to equipment	45,514	46,923	46,980
Furniture and accessories	350	363	368
Utilities	410	420	420
Merchandise	19,925	19,925	19,925
Cost of flood fighting and debris removal	2,329	2,329	2,329
Cost of evacuation	3,687	3,687	3,687
Cost of cleanup and rehabilitation	1,527	1,519	1,519
Loss of wages	(10,752)(1) 7,446	(10,752)(1) 7,446	(10,752)(1) 7,446
Loss of profit	(6,035)(1) 3,705	(6,035)(1) 3,705	(6,035)(1) 3,705
Other(2)	1,020	1,020	1,020
Total	91,959	93,538	93,756

(1) Numbers in ( ) indicate amounts reported in damage interviews but not used in total for analysis.

(2) Includes costs to transfer business accounts and added costs for transportation of products from other areas of the country to satisfy demands.

Damages by category
for new firms and additions interviewed in 1981
Riverview Industrial Area
(1981 prices and conditions)

Damage category	Damages at barrier overtop	Damages at barrier overtop plus 4 ft.	Damages at barrier overtop plus 6 ft.
	($1,000's)	($1,000's)	($1,000's)
Transportation	-	-	-
Damage to buildings	350.0	360.0	370,0
Damage to equipment	165.0	170.0	170.0
Furniture and accessories	-	-	-
Utilities	-	-	-
Merchandise	25.0	25.0	25.0
Cost of flood fighting and debris removal	4.0	4.0	4.0
Cost of evacuation	75.0	75.0	75.0
Cost of cleanup and rehabilitation	41.0	43.0	43.0
Loss of wages	(7.0) (1) 0 (2)	(7.0) (1) 0 (2)	(7.0) (1) 0 (2)
Loss of profit	(60.0) (1) 0 (2)	(60.0) (1) 0 (2)	(60.0) (1) 0 (2)
Other	750.0 (3)	750.0 (3)	750.0 (3)
Total	(1,477.0) (1) 1,410.0 (2)	(1,494.0) (1) 1,427.0 (2)	(1,504.0) (1) 1,437.0 (2)

(1) Reported values.
(2) Values used in analysis.
(3) Irretrievable losses in services to regional nonprofit health facility.

Damages by category
for
Units not interviewed in 1981 but interviewed previously

Damage category	Damages at barrier overtop ($1,000's)	Damages at barrier overtop plus 4 ft. ($1,000,s)	Damages at barrier overtop plus 6 ft. ($1,000's)
Transportation	22.4	22.4	22.4
Damage to buildings	511.1	547.0	560.7
Damage to equipment	1,376.4	1,492.8	1,563.6
Furniture and accessories	349.0	370.6	370.6
Utilities	468.9	489.5	502.3
Merchandise	508.0	510.2	511.0
Flood fighting	667.8	722.9	755.9
Cost of evacuation	963.4	1,172.0	1,191.0
Cost of cleanup and rehabilitation	1,141.8	1,289.0	1,300.0
Loss of wages reported	(2,882.1)[1]	(3,049.3)[1]	(3,127.4)[1]
Loss of profits used	0	0	0
Total - July 1981 prices, survey conditions	6,008.8	6,616.4	6,777.5
Total - July 1981 prices, updated conditions[2]	8,286.0	9,187.0	9,434.0

(1) Number in ( ) shows sum of lost profits and wages reported during interviews. As shown, no credit for these values was given in the analysis as without another interview their applicability to losses in National Economic Development could not be substantiated.

(2) Flood damages, exclusive of wages and profits, for the 13 major damage units rose by a factor of 1.379 from previous interviews. Flood damages for the above units are presumed to have risen at a rate consistent with the larger damage units.

The following table shows the summation of damages for 1981 prices and conditions. It includes provisions for public damages to streets and other public facilities that would occur in the study area.

Summary
Damages in Riverview Industrial Area
for
July 1981 price levels and conditions

Item	Damages at barrier overtop	Damages at barrier overtop plus 4 ft.	Damages at barrier overtop plus 6 ft.
	($1,000's)	($1,000's)	($1,000's)
Thirteen major damage firms	91,959	93,538	93,756
New firms and additions	1,410	1,427	1,437
Units not interviewed in 1981, but interviewed previously	8,286	9,187	9,434
Public damages	200	250	300
Total	101,855	104,402	104,927

FUTURE GROWTH ANALYSIS

Existing Development

As mentioned before, 13 major damage-prone businesses were interviewed in July 1981. Future increases in damages were projected independently for each business enterprise. Past patterns of internal growth and the growth horizon were discussed with a firm manager or entrepreneur at each business. Based on these interviews, realistic decisions were made concerning production capabilities, inventories and/or stock material growth, production equipment improvement, evacuation capability and plans, sources of profit growth, and changes in labor inputs (loss of wages). Rates of change and timing of changes for damages sustained were uniquely determined for each firm studied. Because of the limited number of businesses sustaining the vast majority of damages and

the clear possibility for unauthorized disclosure, the table of individual company damage projections is not included here. However, the percent of damage increase (compounded annual real growth) is shown in the first table on page 5-14. Analyses of individual business growth work sheets are available for review by appropriate authorities. Most businesses' planning horizons are 5 years or less and, for those companies, growth is considered from 1981 through 1986. For firms with longer horizons, growth through 1991 was evaluated. No growth was considered beyond 1991.

In a manner similar to the above, the growth of the new firms and additions for the period between 1981 and 1986 was analyzed. A tabulation of the growth that those are projected to achieve is shown in the second table on page 5-14.

Growth in flood damages for 13 major firms[1]

Period of growth	Depth of flooding	Growth[2] in damages by firm in percent per year: A	B	C	D	E	F	G	H	I	J	K	L	M	Average growth in percent	Sum of damages ($1,000's): 1981	1986	1991	Weighted average annual growth rate in percent
1981-1986	Barrier overtop	7.5	6.8	0	5.9	0	2.2	0	6.9	0	10.0	5.9	8.4	0	4.1	91,959	119,805		5.4(3)
	Overtop plus 4 feet	7.5	6.7	0	5.9	0	2.2	0	6.8	0	10.0	5.9	8.4	0	4.1	93,538	121,911		5.4(3)
	Overtop plus 6 feet	7.5	6.7	0	5.9	0	2.2	0	6.8	0	10.0	5.9	8.4	0	4.1	93,538	121,911		5.4(3)
1986-1991	Barrier overtop	4.0	1.0	0	5.9	0	0	0	0	0	0	0	2.8	0	1.1		119,805	139,642	3.1(4)
	Overtop plus 4 feet	4.0	1.0	0	5.9	0	0	0	0	0	0	0	2.8	0	1.1		121,911	141,753	3.1(4)
	Overtop plus 6 feet	4.0	1.0	0	5.9	0	0	0	0	0	0	0	2.8	0	1.1		122,244	142,086	3.1(4)

(1) First floor flooding ranges from 3.1 feet for firm F to 9.6 feet for firm G at overtop and averages 6.8 feet. The average depth of first floor flooding for a standard project flood would be about 14 feet.
(2) Growth rates shown are compounded annual rates.
(3) (Composite total damage projected in 1986 ÷ composite total damages in 1981)$^{.2}$ - 1.
(4) Growth rates for 1986 to 1991 calculated similar to 1981 to 1986 growth.

Growth in flood damages for new units and additions which were interviewed in 1981

Period of growth	Depth of flooding	Growth in damages by firm in percent per year[1]: V[2]	W	X	Y	Z[2]	Average growth in percent	Sum of damages ($1,000's): 1981	1986	1991	Weighted average annual growth rate[3][4] in percent
1981-1986	Barrier overtop	1.3	14.8	0	14.9	0	6.2	1,410	1,540		1.8
	Overtop plus 4 feet	1.3	14.8	0	14.9	0	6.2	1,427	1,557		1.8
	Overtop plus 6 feet	1.3	14.8	0	14.9	0	6.2	1,437	1,567		1.7
1986-1991	Barrier overtop	0.2	1.0	0	1.0	0	0.4		1,540	1,558	0.2
	Overtop plus 4 feet	0.2	1.0	0	1.0	0	0.4		1,557	1,575	0.2
	Overtop plus 6 feet	0.2	1.0	0	1.0	0	0.4		1,567	1,585	0.2

(1) Growth rates are compounded annual rates.
(2) Units are those which reported additions from "old" surveys.
(3) (Composite total damage projected in 1986 ÷ composite total damage in 1981)$^{0.2}$ - 1.
(4) Growth rates for 1986 to 1991 calculated similar to 1981 to 1986 growth.

In 1978, a random sample telephone survey was conducted in which 21 of the firms not included in the 1981 surveys were interviewed. These 21 firms are about one-sixth of the lesser flood damage prone businesses but represent about one-quarter of the aggregate damages to those businesses. The purpose of the survey was to assess planned growth in the next decade. Out of the 21 surveyed, 11 indicated projected annual growth in flood damage which varied from 4 to 40 percent. The balance of the firms indicated no projected growth. On the basis of the telephone survey, an annual aggregate rate of near term growth in flood damages for the 21 firms was calculated at about 5 3/4 percent.

For simplicity, firms not interviewed in 1981 were assumed to have growth patterns similar to those of the 13 larger firms. To determine 1981 damages, previously reported damages (1977-1979) were updated in proportion to the growth in damages which the 13 larger firms had experienced. Future growth rates in damages for firms not interviewed were considered to equal the composite rate of the 13 larger firms, an assumption which is supported by the 1978 telephone interviews.

Growth In flood damages for firms not
interviewed in 1981 (but interviewed previously)
(1981 prices, updated conditions)

Period of growth	Depth of flooding	Weighted growth of 13 major Damage firms (1)	Sum of damages ($1,000's) 1981	1986	1991
	Barrier overtop	5.4	8,286	10,794	
1981-1986	Overtop plus 4 feet	5.4	9,187	11,973	
	Overtop plus 6 feet	5.4	9,434	12,301	
	Barrier overtop	3.1		10,794	12,581
1986-1991	Overtop plus 4 feet	3.1		11,973	13,923
	Overtop plus 6 feet	3.1		12,301	14,297

(1) Assumes that firms not interviewed in 1981 grow at the same rate as the larger damage firms.

DEVELOPMENT CONDITIONS BY BASE YEAR

The base year for the project is 1986. By 1986 the remaining usable land will be developed. Although St. Paul building codes require raising new floodplain structures at least 1 foot above the 100-year floodplain, this requirement does not apply in the Riverview area since it is protected to the 167-year flood level by the existing project. The St. Paul Port Authority, the prime developer of the Riverview Industrial Area, anticipates all land will have some development on it by 1986. Rapid growth has been exhibited between surveys, expanding damages at overtop from an estimated $27.2 million in 1978 conditions to the current value of $101.9 million. Land sales are expected to continue, and full development by 1986 is attainable.

Of the total currently protected vacant land (about 67 acres), 17 acres is zoned limited development because of restrictions imposed by airport clear zone requirements; 8 acres adjoin developed parcels and was considered in the growth to existing development above. The land use information in this report was generally based on summer 1981 conditions. However, a reevaluation on vacant land was conducted in March 1982 and it revealed that since summer 1981 parcel sales, construction, and definite plans for construction before 1986 have occurred at a rate even greater than that for the period 1976 to 1979. As of the summer of 1981 the Port Authority held 36 acres of developable land. By March 1982 23.0 acres had been sold. Construction of office, warehouse, or manufacturing facilities is scheduled on 22 of the 23 acres in calendar year 1982; construction on the remaining acre will take place in 1983 and 1984. Therefore, as of March 1982, the Port Authority had only 13 of the 36 acres of developable land remaining to be sold.

The developable acreages identified also include vacant lands in private ownership. These total 14 acres of which 8 acres are considered in the development plans of companies with existing development on the same parcel. The remaining privately held acreage is in two parcels of 3 acres each. One of the two owners was contacted and indicated that plans have been prepared for development of the parcel but would not state when development is scheduled to take place.

In summary, as of the summer of 1981, 50 acres remained vacant and developable. As of March 1982 sales, construction, and planned construction have been identified for 34.0 acres or 68 percent of the developable land. At that rate all remaining lands would be developed before the 1986 project completion date.

Development on the parcels which constitute the 42 acres (50 available minus eight considered in growth to existing development) was assumed to consist of industries similar to those already existing in the Riverview Industrial Area. Existing industries which occupy similar sized parcels, with similar access and transportation requirements, were superimposed on vacant lands. In all, an additional 17 businesses were assumed to be in place in 1986. Two of these seventeen were included in the thirteen major damage firms interviewed. The 17 original businesses accounted for about 5.8 percent of the 1981 flood damages at overtop. Elevation damage relationships for the 17 new units were assumed to be the same as those for the original units.

Damages for the new units from 1986 through 1991 were considered to grow at the average growth rate of damages of the 13 major damage firms for the same period. No growth for new businesses was considered after 1991. The following table shows the damages assumed for new growth through 1991 for each of the survey damage points.

In summary, damages at three damage elevations (barrier overtop, barrier overtop plus 4 feet, and barrier overtop plus 6 feet) were computed for 1981, 1986 and 1991 conditions. The table on page 5-19 shows the values which are used to define the depth-damage curves described in the following section.

Damages to new development ($1,000's)

Firm identification number	Parcel size (acres)	1981 damages	1986 damages(1)			1991 damages(2)		
			Overtop	Overtop plus 4 ft.	Overtop plus 6 ft.	Overtop	Overtop plus 4 ft.	Overtop plus 6 ft.
1N	1.2	0	89.8	89.8	89.8	94.8	94.8	94.8
2N	0.5	0	132.0	138.6	138.6	139.4	146.4	146.4
3N	1.4	0	27.4	29.8	30.9	28.9	31.5	32.6
4N	8.1	0	3,437.0	3,114.0	3,457.0	3,630.2	3,340.0	3,650.1
5N	2.6	0	28.4	28.4	28.4	30.0	30.0	30.0
6N	4.3	0	234.7	250.1	252.3	247.9	264.2	266.5
7N	2.3	0	155.3	155.3	155.3	164.0	164.0	164.0
8N	1.0	0	27.7	27.7	27.7	29.3	29.3	29.3
9N	1.9	0	39.0	48.1	48.1	41.2	50.8	50.8
10N	3.3	0	28.4	28.4	28.4	30.0	30.0	30.0
11N	3.0	0	161.0	161.0	161.0	170.0	170.0	170.0
12N	0.7	0	16.3	19.0	20.4	17.2	20.1	21.5
13N	1.2	0	80.0	80.0	80.0	84.5	84.5	84.5
14N	4.7	0	127.6	131.0	136.5	134.8	138.4	144.2
15N	0.4	0	60.8	62.5	64.5	64.3	66.2	67.8
16N	2.9	0	1,122.0	1,122.0	1,122.0	1,185.0	1,185.0	1,185.0
17N	2.6	0	121.7	125.0	128.0	128.5	132.0	135.5
	42./A		5,889.1	5,943.7	5,968.9	6,220.0	6,277.0	6,303.0

(1) Considers the use of 1981 prices and condition of the 17 firms. Damages shown are reported values less profits and wages reported as lost.

(2) Damages in 1991 are the 1986 damages projected to rise at the average of the 13 major damage firms.

Summary of damages ($1,000's)
for
Riverview Industrial Area
Present, 1986, and 1991 conditions
(July 1981 price levels)

Item	1981			1986			1991		
	Barrier overtop	Barrier overtop plus 4 feet	Barrier overtop plus 6 feet	Barrier overtop	Barrier overtop plus 4 feet	Barrier overtop plus 6 feet	barrier overtop	Barrier overtop plus 4 feet	Barrier overtop plus 6 feet
Damages to 13 major damage firms	91,959	93,538	93,756	119,805	121,911	122,244	139,642	141,753	142,086
Damages to new firms and additions	1,410	1,427	1,437	1,542	1,557	1,567	1,558	1,575	1,585
Damages to firms not interviewed in 1981	8,286	9,187	9,434	10,794	11,973	12,301	12,581	13,923	14,297
Damages to new development in place by 1986	0	0	0	5,889	5,944	5,969	6,220	6,277	6,303
Damages to public property	200	250	300	200	250	300	200	250	300
Total	101,855	104,402	104,927	138,228	141,635	142,381	160,201	163,778	164,571

AVERAGE ANNUAL DAMAGES

The quadrigraph method, which was used to determine average annual damages and benefits, considers all of the floods, both large and small, that can reasonably be expected to occur over the life of project modifications. As described above, flood damages were determined for three different flood levels for present development conditions and for conditions as projected for 1986 and 1991. The three damage points define curves which can be used to determine flood damages for any level of flooding under present, 1986, and 1991 conditions. These stage-damage curves illustrate the basic assumption that no flood damages occur during floods up to the project design flood (168,000 cfs) level. However, as the design level is exceeded, damages instantaneously rise to near those expected during the occurrence of a barrier overtopping flood. The stage-damage curves are shown as the upper right quadrant of plate 5-4.

The upper left area of plate 5-4 shows the rating curve which relates elevations to which the river would rise for a range of river discharges. As shown on plate 5-4, the with-barriers condition rating curve is consistently "higher" for all floods above the design flood as compared with the no-flood barriers condition curve. As the raised barrier design is reached, the rating curve begins to deviate from the with-barrier condition curve.

Barriers are assumed to have an effect on the rating curve even after the barriers are overtopped. The assumed rating curve for the barrier-failed condition is shown as the dashed intermediate curve between the with- and without-barrrier condition curves on plate 5-4. At an elevation about 3 feet above design flood levels the design rating curve unites with the barrier-failed condition rating curve. The design rating curve is used to calculate residual damages. The sensitivity of rating curve assumptions with respect to the economic feasibility of various barrier raise alternatives is discussed later in this appendix.

The lower left hand quadrant of plate 5-4 shows the discharge-frequency curve. Its derivation is discussed in appendix 6. The curve give a visual representation of how often various peak discharges can be expected. For example, the discharge of 168,000 (design flood) equates to a 0.6-percent frequency flood. This means that a flood of that magnitude could be expected to be equaled or exceeded in 0.6 percent of future years. Converting this frequency to a more easily understood number, the recurrence interval, requires dividing 100 by 0.6 and results in the design flood being identifed as a 167-year flood. Since the discharge-frequency curve is based on past records, it may not precisely describe future occurances. The sensitivity of project economics to a range of frequency curves is also discussed later in this appendix.

Combining the stage-damage, rating (stage-discharge), and discharge-frequency curves permits the development of the frequency-damage relationship. The following table shows data used for plotting the curves. The frequency-damage curves, shown as solid and bold dashed lines, are located in the lower right on the quadigraph, plate 5-4. The curves depict the frequency at which various damage levels could be expected to occur with and without project modification for present conditions and for 1986 and 1991 conditions. Integrating the areas bounded by the without-project curves results in average annual damage amounts which can be expected to occur in the future should no project improvements be made. As shown on the quadrigraph, these sum annual damages amount to $604,000, $825,100 and $945,000 for 1981, 1986, and 1991 conditions, respectively. The average annual damage amounts are the total of annual damages of the five categories of damageable firms described previously. Average annual damages for each category were derived using the techniques described above. Those disaggregated annual damages are shown in columns 1, 2 and 3 on the table on pages 5-23 through 5-25.

Frequency, discharge, elevation-damage data

Frequency in percent(1)		Discharge (cfs)(2)	Failed barrier elevation (feet)(3)	With barrier elevation (feet)	Damages ($1,000's) 1981(4)
0.05	Standard project flood	260,000	716.9	717.3	104,700
0.07		246,000	715.8	716.2	103,900
0.10		231,000	714.7	715.0	103,400
0.17	4-foot raise	210,000	713.0	713.3	102,300
0.30	2-foot raise	187,000	711.1	711.4	100,400
0.40		180,000	710.6	710.7	99,300
0.50		174,000	710.1	710.2	98,000
0.60	Current design	168,000	709.7	709.7	96,300

(1) Exceedence frequency in percent.
(2) Cubic feet per second.
(3) Elevation in feet above msl (1912 adjustment) at U.S. Geological Survey gage, Robert Street. These elevations were used in annual damage calculations.
(4) Damages in July 1981 price levels and conditions.

AVERAGE ANNUAL EQUIVALENT DAMAGES

The average annual damages derived by the quadrigraph method result in annual amounts for only the three distinct conditions (1981, 1986, and 1991). Since the proposed barrier raise project life is considered to be 100 years and economic feasibility analyses are concerned with repayment of investment and annual revenues, it is necessary to convert damages (also benefits and costs) to uniform average annual equivalent values. Compound interest methods recognize the difference in present and future values. For this analysis the damages were assumed to grow linearly between 1986 and 1991. No growth in damages was projected beyond 1991 as noted previously. The average annual equivalent damages for the project life (1986-2086) were calculated using a 7 3/8 percent discount rate, and are shown in the right hand columns in the following tables.

Summary

Present and future average annual damages, Riverview Industrial Area[1]

Item	1981	Base year 1986	Projected total flood damages 1991	1996	2006	2016	2026	2036	2086	Increase 1986-2086	Average annual equivalent of increase over 100-year project life[2]	Total average annual equivalent damages
Industrial, commercial, and public damages	$604,800	$825,100	$954,800	$954,800	$954,800	$954,800	$954,800	$954,800	$954,800	$129,700	$113,100	$938,200
Index	0.733	1.000	1.157	1.157	1.157	1.157	1.157	1.157	1.157	-	-	[illegible]
Total	$604,800	$825,100	$954,800	$954,800	$954,800	$954,800	$954,800	$954,800	$954,800	$129,700	$113,100	$938,200

(1) 7 3/8-percent interest rate and July 1981 prices.
(2) Average annual equivalent compound interest factor assuming straight-line growth from 1986 through 1991 and no growth thereafter.

Present and future average annual damages for thirteen major damage firms interviewed in 1981, Riverview Industrial Area[1]

Item	1981	Base year 1986	Projected total flood damages 1991	1996	2006	2016	2026	2036	2086	Increase 1986-2086	Average annual equivalent of increase over 100-year project life[2]	Total average annual equivalent damages
Damages for thirteen major damage firms	$547,000	$714,600	$831,400	$831,400	$831,400	$831,400	$831,400	$831,400	$831,400	$116,800	$101,800	$816,500
Index	0.765	1.000	1.163	1.163	1.163	1.163	1.163	1.163	1.163	-	-	1.142
Total	$547,000	$714,600	$831,400	$831,400	$831,400	$831,400	$831,400	$831,400	$831,400	$116,800	$101,800	$816,500

(1) 7 3/8-percent interest rate and July 1981 prices.
(2) Average annual equivalent compound interest factor assuming straight-line growth from 1986 through 1991 and no growth thereafter.

Present and future average annual damages for new firms and additions (interviewed in 1981), Riverview Industrial Area(1)

Item	1981	Base year 1986	Projected total flood damages 1991	1996	2006	2016	2026	2036	2086	Increase 1986-2086	Average annual equivalent of increase over 100-year project life(2)	Total average annual equivalent damages
Damages for new firms and additions	$8,500	$9,200	$9,400	$9,400	$9,400	$9,400	$9,400	$9,400	$9,400	200	200	$9,400
Index	0.924	1.000	1.022	1.022	1.022	1.022	1.022	1.022	1.022	-	-	1.022
Total	$8,500	$9,200	$9,400	$9,400	$9,400	$9,400	$9,400	$9,400	$9,400	200	200	$9,400

(1) 7 3/8-percent interest rate and July 1981 prices.
(2) Average annual equivalent compound interest factor assuming straight-line growth from 1986 through 1991 and no growth thereafter.

Present and future average annual damages for firms not interviewed in 1981
(but interviewed previously)
Riverview Industrial Area(1)

Item	1981	Base year 1986	Projected total flood damages 1991	1996	2006	2016	2026	2036	2086	Increase 1986-2086	Average annual equivalent of increase over 100-year project life(2)	Total average annual equivalent damages
Damages for firms not interviewed in 1981	$48,100	$64,800	$75,500	$75,500	$75,500	$75,500	$75,500	$75,500	$75,500	$10,700	$9,300	$74,100
Index	0.742	1.000	1.165	1.165	1.165	1.165	1.165	1.165	1.165	1.165	-	1.144
Total	$48,100	$64,800	$75,500	$75,500	$75,500	$75,500	$75,500	$75,500	$75,500	$10,700	$9,300	$74,100

(1) 7 3/8-percent interest rate and July 1981 prices.
(2) Average annual equivalent compound interest factor assuming straight-line growth from 1986 through 1991 and no growth thereafter.

Present and future average annual damages for new development in place by 1986

Riverview Industrial Area[1]

Item	1981	Base year 1986	Projected total flood damages 1991	1996	2006	2016	2026	2036	2086	Increase 1986-2086	Average annual equivalent of increase over 100-year project life[2]	Total average annual equivalent damages
Damages for new growth	0	$35,300	$37,300	$37,300	$37,300	$37,300	$37,300	$37,300	$37,300	$2,000	$1,700	$37,000
Index	0	1.000	1.057	1.057	1.057	1.057	1.057	1.057	1.057	-	-	1.048
Total		$35,300	$37,300	$37,300	$37,300	$37,300	$37,300	$37,300	$37,300	$2,000	$1,700	$37,000

(1) 7 3/8-percent interest rate and July 1981 prices.
(2) Average annual equivalent compound interest factor assuming straight-line growth from 1986 through 1991 and no growth thereafter.

Present and future average annual public damages, Riverview Industrial Area[1]

Item	1981	Base year 1986	Projected total flood damages 1991	1996	2006	2016	2026	2036	2086	Increase 1986-2086	Average annual equivalent of increase over 100-year project life	Total average annual equivalent damages
Public damages	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	0	0	$1,200
Index	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Total	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200

(1) 7 3/8-percent interest rate and July 1981 prices.

AVERAGE ANNUAL RESIDUAL DAMAGES AND NEGATIVE BENEFITS

Average annual residual damages are those damages which would remain after the project is operational. They would occur when and if floods exceed the new higher design level. Since the chance of a flood greater than the design flood becomes less probable as the design level of protection is increased, the residual damages become smaller with higher barrier raises.

Average annual residual damages for each of the three optional scales of development for each of the three time periods (1981, 1986, and 1991) were derived using the quadrigraph method described above. Plate 5-4 identifies the frequency-damage curves for each of the three optional raises. The curves are shown as fine dashed and dotted lines. As with average annual damages, residual average annual damages are the integrated areas bounded by the frequency-damage curves. It should be noted that the dotted lines lie slightly outside of the bold dashed average annual damage curves. This shows that construction of barrier raise would slightly aggravate flood damages if a design topping flood were to occur and reflects the rating curve assumption described earlier. Columns 2, 3, and 4 of the table on page 5-29 show the values of average annual residual damages tabulated in the summary form. Average annual equivalent residual damages are shown on the far right column of that table. These values were calculated in a similar manner to the average annual equivalent damages described previously.

In addition to the residual damages which would occur within the study area, a stage raise caused by any barrier height increase would slightly aggravate flood damages upstream during very rare flood events. These damages were taken into account. They are defined as negative benefits and were evaluated as described below.

The raise in the St. Paul flood barrier for the three alternatives will cause backwater effects from the project area as far upstream as locks and dam 1, about 7 1/2 miles. Three water surface profiles were developed showing the water surface elevation for the standard project flood raise at 260,000 cfs, the 4-foot barrier raise at 210,000 cfs, and the 2-foot barrier raise at 187,000 cfs. These data indicate that the stage increase would range from 1.0 foot for the standard project flood to 0.4 foot for the 2-foot barrier raise at the upstream end of the flood control project. Upstream of the lock, the stage increase would be negligible. In all, 27 damageable units would be affected by the backwater stage increases caused by a project barrier raise. These stage raises were translated into negative average annual benefits as shown in the following table. Average annual negative benefits were derived by development of elevation-damage and frequency-damage curves based on field surveys of damages.

Negative average annual benefits

Alternative	Negative benefits(1)
2-foot barrier raise	$3,900
4-foot barrier raise	6,000
Standard project flood barrier raise	7,300

(1) Assumes design flood elevation plus freeboard.

Several businesses have been torn down during the past few years. This trend will probably continue and would cancel any content growth which would take place in remaining units. Therefore, future growth was not included in the negative benefits. Damage increases are projected to offset damage decreases in this unprotected floodplain.

AVERAGE ANNUAL BENEFITS

Average annual benefits for each of the three optional barrier raises are simply the difference between average annual damages which would occur if the existing project were not altered and the amount of damages plus negative benefits which are projected to occur if the barrier is raised. Average annual benefits for each barrier raise option for the 1981, 1986, and 1991 conditions as well as the average annual equivalent benefits which would be expected to occur over the project life are shown on the following table. Average annual benefits designated by damage category for the selected 4-foot barrier raise are shown in the tables on pages 5-30 through 5-32.

Summary

Average annual residual damages, negative benefits, and benefits (1) for the 2-foot, 4-foot, and 8-foot (SPF) barrier raises

Item	1981	Base year 1986	1991	1996	2006	2016	2026	2036	2086	Increase 1986-2086	Average annual equivalent of increase over 100-year project life	Total average annual equivalent benefits
Total average annual damages without project	604,800	825,100	954,800	954,800	954,800	954,800	954,800	954,800	954,800	129,700	113,100	938,200
2-foot barrier raise												
Total average annual residual damages	(310,200)(2)	(419,400)	(484,500)	(484,500)	(484,500)	(484,500)	(484,500)	(484,500)	(484,500)	(65,100)	(56,800)	(476,200)
Total average annual negative benefits	(3,900)(2)	(3,900)	(3,900)	(3,900)	(3,900)	(3,900)	(3,900)	(3,900)	(3,900)	0	0	(3,900)
Total average annual benefits	290,700	401,800	466,400	466,400	466,400	466,400	466,400	466,400	466,400	64,600	56,300	458,100
4-foot barrier raise												
Total average annual residual damages	(183,300)	(245,900)	(283,000)	(283,000)	(283,000)	(283,000)	(283,000)	(283,000)	(283,000)	(37,100)	(32,400)	(278,300)
Total average annual negative benefits	(6,000)	(6,000)	(6,000)	(6,000)	(6,000)	(6,000)	(6,000)	(6,000)	(6,000)	0	0	(6,000)
Total average annual benefits	421,500	579,200	671,800	671,800	671,800	671,800	671,800	671,800	671,800	92,600	80,700	659,900
Standard project flood barrier raise												
Total average annual residual damages	(52,500)	(73,300)	(82,500)	(82,500)	(82,500)	(82,500)	(82,500)	(82,500)	(82,500)	(11,200)	(9,800)	(81,100)
Total average annual negative benefits	(7,300)	(7,300)	(7,300)	(7,300)	(7,300)	(7,300)	(7,300)	(7,300)	(7,300)	0	0	(7,300)
Total average annual benefits	545,000	746,500	865,000	865,000	865,000	865,000	865,000	865,000	865,000	118,500	103,300	849,800

(1) 7 5/8-percent interest rate and July 1981 prices.

(2) ( ) indicate that the numbers are subtracted from total average annual damages to arrive at total average annual benefits.

Average annual benefits for a 4-foot barrier raise from thirteen major damage firms interviewed in 1981[1]

Item	1981	Base year 1986	1991	1986	2006	2016	2026	2036	2086	Increase 1986-2086	Average annual equivalent of increase over 100-year project life[2]	Total average annual benefits
Average annual benefits with 4-foot barrier raise from 13 major damage firms	$386,800	$511,200	$591,600	$591,600	$591,600	$591,600	$591,600	$591,600	$591,600	$80,400	$70,000	$581,200
Index	0.757	1.000	1.157	1.157	1.157	1.157	1.157	1.157	1.157	--	--	1.157
Total	$386,800	$511,200	$591,600	$591,600	$591,600	$591,600	$591,600	$591,600	$591,600	$80,400	$70,000	$581,200

(1) 7 3/8 percent interest rate and July 1981 prices, *not* including provision for negative benefits.
(2) Average annual equivalant compound interest factor assuming straight line growth from 1986 through 1991 and no growth thereafter.

Average annual benefits for a 4-foot barrier raise from new firms and additions (interviewed in 1981)[1]

Item	1981	Base year 1986	1991	1986	2006	2016	2026	2036	2086	Increase 1986-2086	Average annual equivalent of increase over 100-year project life (2)	Total average annual benefits
Average annual benefits with 4-foot barrier raise from new firms and additions (interviewed in 1981)	$6,000	$6,500	$6,700	$6,700	$6,700	$6,700	$6,700	$6,700	$6,700	200	200	$6,700
Index	0.923	1.000	1.031	1.031	1.031	1.031	1.031	1.031	1.031	--	--	1.031

(1) 7 3/8 percent interest rate and July 1981 prices, not including provision for negative benefits.
(2) Average annual equivalant *compound interest factor* assuming straight line growth from 1936 through 1991 and no growth thereafter.

Average annual benefits for a 4-foot barrier raise from firms not interviewed in 1981 (but interviewed previously)(1)

Item	1981	Base year 1986	1991	1986	2006	2016	2026	2036	2086	Increase 1986-2086	Average annual equivalent of increase over 100-year project life (2)	Total average annual benefits
Average annual benefits with 4-foot barrier raise from firms not interviewed in 1981	$34,000	$43,100	$52,300	$52,800	$52,800	$52,800	$52,800	$52,800	$52,800	$9,700	$8,500	$51,600
Index	0.783	1.000	1.225	1.225	1.225	1.225	1.225	1.225	1.225	--	--	1.197
Total	$34,000	$43,100	$52,800	$52,800	$52,800	$52,800	$52,800	$52,800	$52,800	$9,700	$8,500	$51,600

(1) 7 3/8 percent interest rate and July 1981 prices, not including provision for negative benefits.
(2) Average annual equivalant compound interest factor assuming straight line growth from 1986 through 1991 and no growth thereafter.

Average annual benefits for a 4-foot barrier raise from new development(1)

Item	1981	Base year 1986	1991	1986	2006	2016	2026	2036	2086	Increase 1986-2086	Average annual equivalent of increase over 100-year project life(2)	Total average annual benefits
Average annual benefits with 4-foot barrier raise from new development in place by 1986	0	$23,700	$26,000	$26,000	$26,000	$26,000	$26,000	$26,000	$26,000	$2,300	$2,000	$25,700
Index	0.000	1.000	1.097	1.097	1.097	1.097	1.097	1.097	1.097	--	--	1.08[illegible]
Total	0	$23,700	$26,000	$26,000	$26,000	$26,000	$26,000	$26,000	$26,000	$2,300	$2,000	$25,700

(1) 7 3/8 percent interest rate and July 1981 prices, not including provision for negative benefits.
(2) Average annual equivalent compound interest factor assuming straight line growth from 1986 through 1991 and no growth thereafter.

Average annual benefits for a 4-foot barrier raise from public damage reductions[1]

Item	1981	Base year 1986	1991	1986	2006	2016	2026	2036	2086	Increase 1986-2086	Average annual equivalent of increase over 100-year project life[2]	Total average annual benefits
Average annual benefits with 4-foot barrier raise from public damage reduction	$700	$700	$700	$700	$700	$700	$700	$700	$700	0	0	$700
Index	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	--	--	1,000
Total	$700	$700	$700	$700	$700	$700	$700	$700	$700	0	0	$700

(1) 7 3/8 percent interest rate and July 1981 prices, not including provision for negative benefits.
(2) Average annual equivalent compound interest factor assuming straight line growth from 1986 through 1991 and no growth thereafter.

ECONOMIC JUSTIFICATION

The selected plan 4-foot raise would result in average annual benefits of $659,900, which includes $6,000 negative benefits. Average annual costs of $520,000 (described on page 3-8 in Appendix 3) applied to these benefits provides a benefit-cost ratio of 1.27. The benefit-cost ratio for the 1986 base year condition is 1.11.

SENSITIVITY ANALYSIS

SENSITIVITY TO INTEREST RATES

The internal rate of return (the rate of interest at which benefits equal costs over the period of analysis) is approximately 9.2 percent for the 4-foot barrier raise design. The following table shows the relationships between the interest rates and benefit-cost ratios for three alternative designs.

Benefit-cost ratios at various interest rates and designs

Design	Interest rate (percent)	Benefit-cost ratio	Internal rate of return
2-foot raise	5.0	1.88	
	6.0	1.55	
	7.375	1.25	
	8.0	1.14	
	9.0	1.00	9 percent
	10.0	0.89	
4-foot raise	5.0	1.91	
	6.0	1.58	
	7.375	1.27	
	8.0	1.16	
	9.0	1.02	9.2 percent
	10.0	0.91	
SPF raise	4.0	1.21	4.9 percent
	5.0	0.97	
	6.0	0.80	
	7.375	0.64	
	8.0	0.59	
	9.0	0.52	
	10.0	0.46	

SENSITIVITY TO EVACUATION ASSUMPTIONS

Flood damage surveys conducted before 1981 for the Riverview Industrial Area considered that all readily movable property could be evacuated prior to a flood which would overtop or breach the barrier. During the survey of the 13 major damage firms, however, the length of time required to evacuate and the likelihood that firms would evacuate should a large flood be predicted was evaluated. Of the 13 firms interviewed, only 3 reported that they would evacuate as completely as possible if the flood were predicted to crest 1 foot below the top of the barrier. If an overtopping flood crest were predicted, however, all except one said that they would evacuate. Time required for full evacuation of the firms varied from 1 day to 1 month. The average time required for the evacuation was about 1 week. Two firms, however, reported that it would take from 3 weeks to 1 month for full evacuation.

One of those firms would require special railroad cars and guaranteed rail access for the evacuation. Rail access is closed to the area at flood elevation 701 or a discharge of about 85,000 cfs. That flow was reached 5 days before the 1965 flood crest. Unless an overtopping flood crest could be predicted accurately at least 1 month in advance, this firm could not possibly evacuate all of its commodities. Since prediction is highly dependent upon rainfall and melt conditions during the spring runoff period and peaks can only be accurately predicted 1 to 2 weeks in advance, this firm was considered to be 50-percent evacuated during an overtopping flood.

The other firm would not evacuate with a crest prediction within 1 foot of the top because of the time and cost involved in moving heavy equipment related to its manufacturing. Many of the pieces weigh between 35 and 40 tons. However, some could be dismantled and moved by truck, possibly avoiding the need for rail transportation. For this firm, two thirds of the machinery and inventory were considered evacuated prior to the flood.

The other firms were considered to be evacuated during an overtop spring flood event.

An analysis was performed to determine the sensitivity of damages and resulting benefits to varying degrees of evacuation. Assumptions varying from no evacuation to full evacuation of the 13 major damage firms were evaluated. Full evacuation was considered for the balance of the damage units for all evacuation assumptions. Growth assumptions used prior in this section were used for all damage units. As shown on the following table, project economic feasibility is greatly enhanced by the assumption of less evacuation. Since 77 percent of the major damage firms said that they would not evacuate for a flood greater than the project design (but within the barrier freeboard), the assumption of less evacuation may be warranted. Interestingly, the standard project barrier raise is not economical except for the no evacuation assumption.

Average annual damages and benefits with different evacuation assumptions(1)

Evacuation assumption	1981	1986	1991-2086	Average annual equivalent damages or benefits	Average annual cost	Benefit-cost
No evacuation						
Average annual damages	$1,022,900	$1,365,900	$1,586,500	$1,558,100	-	-
2-foot raise benefits	498,700	647,100	789,300	771,000	$ 367,900	2.10
4-foot raise benefits	722,100	974,000	1,134,700	1,114,100	520,000	2.14
SPF raise benefits	933,000	1,249,500	1,454,300	1,428,000	1,319,000	1.08
33-percent evacuation						
Average annual damages	843,300	1,121,600	1,309,800	1,285,600	-	-
2-foot raise benefits	411,100	557,400	650,300	638,400	367,900	1.74
4-foot raise benefits	592,300	803,000	934,000	917,200	520,000	1.76
SPF raise benefits	764,500	1,032,300	1,201,800	1,180,000	1,319,000	0.89
67-percent evacuation						
Average annual damages	651,600	1,880,000	1,026,500	1,007,700	-	-
2-foot raise benefits	315,900	434,200	504,500	495,500	367,900	1.35
4-foot raise benefits	457,600	625,600	729,000	715,700	520,000	1.38
SPF raise benefits	591,300	804,200	935,300	918,500	1,319,000	0.70
Assumed evacuation						
Average annual damages	604,800	825,100	954,800	938,200	-	-
2-foot raise benefits	290,700	401,800	466,400	458,100	367,900	1.25
4-foot raise benefits	421,500	579,200	671,800	659,900	520,000	1.27
SPF raise benefits	545,000	746,500	865,000	849,000	1,319,000	0.64
100-percent evacuation						
Average annual damages	470,700	642,700	752,000	737,900	-	-
2-foot raise benefits	238,900	311,500	361,200	354,800	367,900	0.96
4-foot raise benefits	325,300	451,200	523,200	514,000	520,000	0.99
SPF raise benefits	420,500	583,100	676,800	664,800	1,319,000	0.50

(1) 7 3/8-percent interest rate, July 1981 price levels.

SENSITIVITY OF FREQUENCY CURVE CONFIDENCE

The record of annual peak flows at a site is a random sample of the underlying population of annual peaks and can be used to estimate the frequency curve of that population. If the same size random sample could be selected from a different period of time, a different estimate of the underlying population frequency curve probably would result. Thus, an estimated flood frequency curve can only be an approximation to the true frequency curve of the underlying population of annual flood peaks. To gauge the accuracy of this approximation, one may construct an interval or range of hypothetical frequency curves that, with a high degree of confidence, contains the population frequency curve. Such intervals are called confidence limits.

Plate 6-1 in Appendix 6, Hydrologic Analysis, shows the frequency-discharge curve and the 0.05 and 0.95 confidence limits. The confidence limits curves were used to develop damages and benefits for each of the three barrier raise options. The following table shows the results of the analysis and indicates that project economics is highly dependent upon frequency-discharge curve confidences. However, the potential for more rather than less project benefits appears probable. Since the St. Paul streamflow gage has been in existance for over 100 years, the curve shown on plate 6-1 probably describes the underlying population of annual peaks quite well. However, the three highest annual peak plotting points are above the existing frequency curve and tend toward the 0.05-confidence limit curve. This might imply that the project benefits claimed by the use of the accepted frequency curve fairly reflect conditions that are expected to occur in the project area with respect to river flow-frequency for the future; but if the frequency-discharge curve is modified because of future high flood events, the curve would more likely shift toward the 0.05-confidence curve. This shift would result in greater economic feasibility for the proposed improvements.

Summary comparison
of the
sensitivity of project economics comparing the use of
confidence limit frequency curves to the accepted frequency curve
($1000's, 7 3/8 percent, July 1981 prices)

	Accepted frequency curve analysis	Analysis using 0.05 limit curve	Analysis using 0.95 limit curve	Upside potential		Downside risk	
					% of value used		% of value used
Total average annual damages	938.2	2,214.0	312.0	1,275.8	136	-626.2	- 67
SPF raise							
Annual benefits	849.8	1,858.0	295.0	1,008.2	119	-554.8	- 65
Residual damages	88.4	356.0	17.0	267.6	303	- 71.4	- 81
Annual cost	1,319.0	1,319.0	1,319.0	0	0	0	0
Net benefits	-469.2	+539.0	-1,024.0	1,008.2	215	-554.8	-118
B/C ratio	0.64	1.68	0.24				
4-foot raise							
Annual benefits	659.9	1,309.0	247.0	649.1	98	-412.9	- 63
Residual damages	278.3	905.0	65.0	626.7	225	-213.3	- 77
Annual cost	520.0	520.0	520.0	0	0	0	0
Net benefits	+139.9	+789.0	-273.0	649.1	464	-412.9	-295
B/C ratio	1.27	2.52	0.48				
2-foot raise							
Annual benefits	458.1	761.0	169.0	302.9	66	-289.1	- 63
Residual damages	480.1	1,453.0	143.0	972.9	203	-337.1	- 70
Annual cost	367.9	368.0(1)	368.0(1)	0	0	0	0
Net benefits	+90.2	+393.0	-225.0	302.8	336	-315.2	-349
B/C ratio	1.25	2.07	0.46				

(1) Rounded up from $367.9.

SENSITIVITY TO BARRIER FAILURE ASSUMPTION

As discussed earlier in this appendix, a barrier raise has the effect of raising stages for rare flood occurrences. The way the project might fail under these conditions and the effect of that failure on the stage-discharge curves and project economics was considered. The following cases for the stage-discharge curve assumption were evaulated:

Case 1 - Assumes the use of the without-barrier condition rating curve for evaluating project damages and benefits associated with a barrier raise.

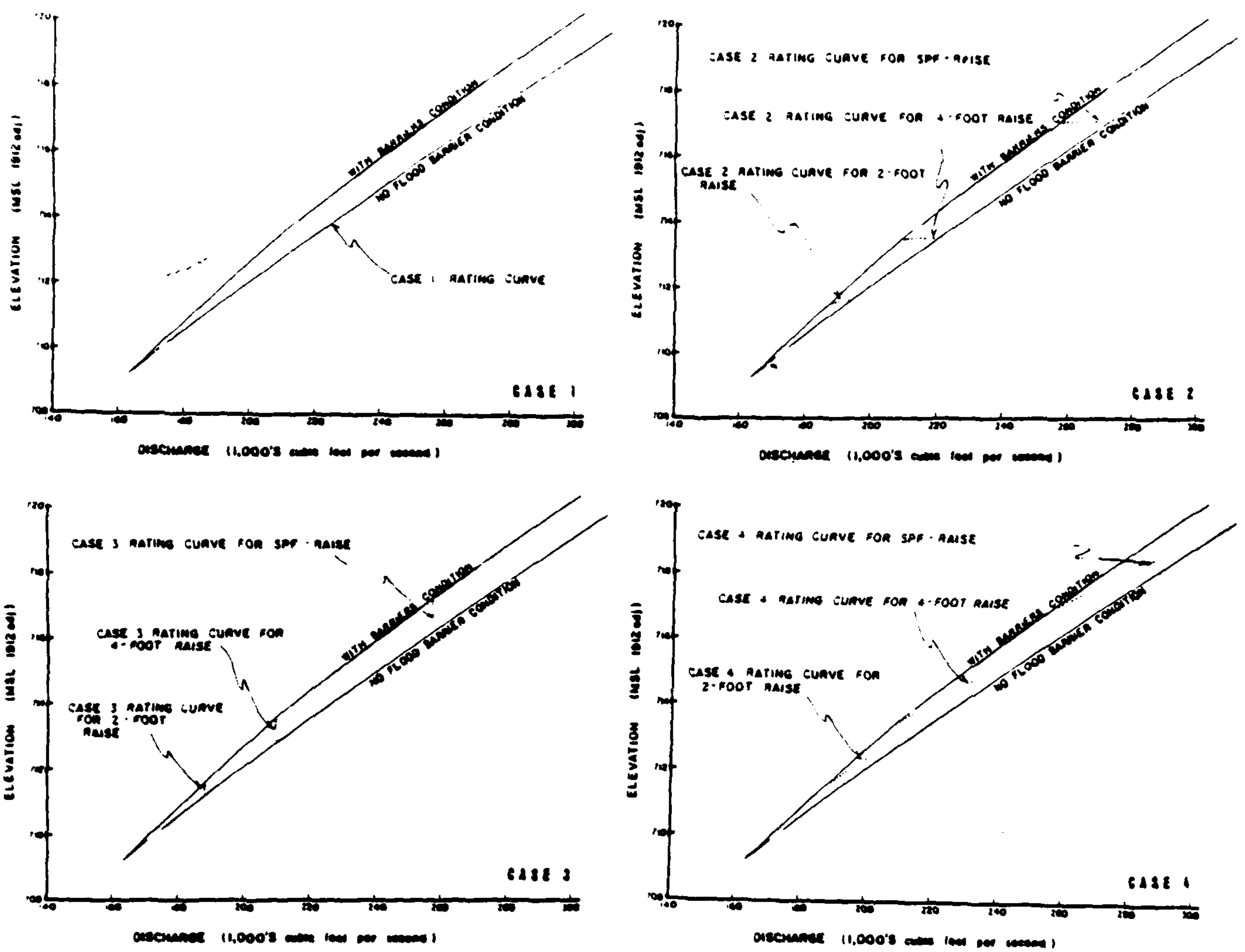
Case 2 - Assumes that, at design level flow, the rating curve runs horizontally between the with-barriers rating curve to the without-barriers condition rating curve. This condition might represent a relatively large levee break in localized area where water stores behind the levee to the level of the river and/or where the levee uniformly gives way once the design level is reached, but the levee remains intact to the design level.

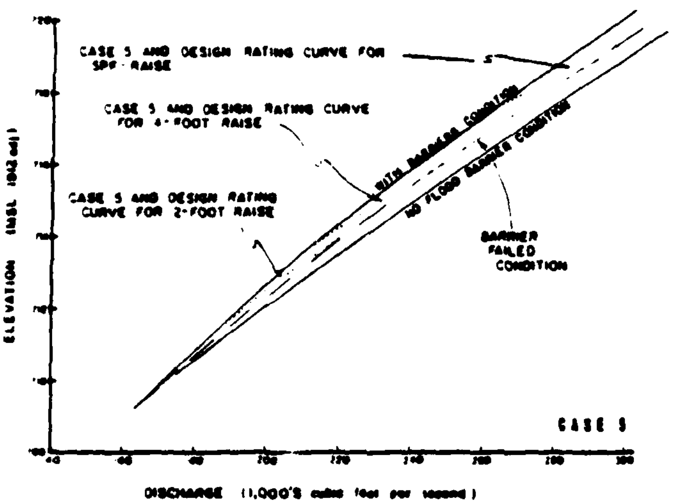
Case 3 - At design level flow, rating curve runs vertically downward from the with-barriers condition to the without-barrier curve. This condition might represent full and complete failure of levee system once the design level is reached.

Case 4 - At design level flow, the elevation of higher flows begins to drop below the level expected with the barrier in place but does not reach the without-barriers rating curve until freeboard is overtopped. This condition might exist with a localized failure of the levee which would allow water inside the protection to equal river level while the remaining barrier affects stage until the barrier is overtopped.

Case 5 - Assumes the barrier-failure condition used in the calculation of project damages and benefits, discussed previously.

The following figure shows graphically the assumed stage-discharge relations for each case.





Stage-discharge relationships for various barrier failure assumptions

The following table, Summary of economic sensitivity to barrier failure assumptions, illustrates the results of the analysis. As shown, the failure assumption has little effect on project benefits. Case 1 shows the most positive effect, but the use of this option is not reasonable because documentation in Appendix 4 shows that a barrier raise will cause stage increases.

Summary of economic sensitivity of barrier failure assumptions (7 3/8 percent - 1981 prices)

	Barrier plan	Degree of protection (expected occurence)	Equivalent[(1)] annual benefits	Average annual costs	Net benefits	Benefit-cost ratio
Case 1						
	2-foot raise	400	$551,900	$ 367,900	$184,000	1.50
	4-foot raise	833	713,800	520,000	193,800	1.37
	8-foot raise	>4000	896,400	1,319,000	-422,600	0.68
Case 2						
	2-foot raise	333	503,000	367,900	135,100	1.37
	4-foot raise	588	698,800	520,000	178,800	1.34
	8-foot raise	2000	872,400	1,319,000	-446,600	0.66
Case 3						
	2-foot raise	333	483,900	367,900	116,000	1.32
	4-foot raise	588	659,800	520,000	139,800	1.27
	8-foot raise	2000	850,200	1,319,000	-468,800	0.64
Case 4						
	2-foot raise	333	483,500	367,900	115,600	1.31
	4-foot raise	588	659,800	520,000	139,800	1.27
	8-foot raise	2000	820,000	1,319,000	-499,000	0.62
Case 5						
	2-foot raise	333	458,100	367,900	90,200	1.25
	4-foot raise	588	659,900	520,000	139,900	1.27
	8-foot raise	2000	849,800	1,319,000	-469,200	0.64

(1) Net of negative upstream benefits.

SENSITIVITY TO THE GROWTH IN DAMAGES

As stated previously, growth rates for all firms interviewed in 1981 were determined individually during interviews with persons representing those firms. This section considers the effect of growth rate projections and timing on the economic feasibiliy of the St. Paul flood control project modifications.

Two growth conditions were evaluated to contrast with the condition which was presented in the above economic analysis. These were the static growth condition and the rapid growth condition.

The static growth condition assumed that flood damage conditions in the study area would remain essentially the same throughout the project life. Damages to the 13 major firms would remain constant at the 1981 surveyed level. Damages for other firms interviewed in 1981 would remain at 1981 levels. Firms not surveyed in 1981 would have flood damages ENR indexed up to 1981 levels from the date of damage surveys. For the static growth condition, currently vacant areas would remain vacant.

The rapid growth condition, as the name implies, considered that the study area damages would grow at a faster rate than that projected from damage survey interviews. For this scenario, damages were assumed to reach the projected 1991 values at an earlier year, 1986. Beyond 1986, damages were projected to grow at a rate of 1 7/8 percent for 50 years which is the projected change in ratio of gross stocks of inventory and equipment to gross stock of structures based on SMSA OBERS projections, 1972 Series E. No growth was projected for the last 50 years of project life.

The following table shows the results of the above analysis. It shows that the economic feasibility of the proposed project modification is very sensitive to damage growth projections used to predict future conditions. With no growth in damages (the static condition), project improvements are clearly not feasible. If the rapid growth projection is chosen, benefits and thus the economic feasibility of a modification is greatly improved over the condition which was used in the basic analysis and derived from interviews.

Sensitivity of growth rate analysis

Growth assumption	Average annual equivalent benefit (1000's)	Average annual costs ($1000's)	Net benefits ($1000's)	Benefit-cost
Static condition				
Average annual damages	584.0	--		
2-foot raise	278.0	367.9	- 89.9	0.76
4-foot raise	406.0	520.0	-114.0	0.78
SPF raise	526.0	1,319.0	-793.0	0.20
Rapid growth condition				
Average annual damages	1,319.6			
2-foot raise	644.4	367.9	276.5	1.75
4-foot raise	928.6	520.0	408.6	1.79
SPF raise	1,195.6	1,319.0	-123.4	0.91

SENSITIVITY TO USE OF LOST PROFITS AND WAGES

Business profit losses and lost wages can be legitimately used as economic flood damages in some cases. These losses are applicable when they result in a net loss to the National economy and cannot be compensated for as national transfers. In the economic analysis of the St. Paul Flood Control Project some wage and profit losses were used for project justification. Those used account for roughly 12 percent of total average annual benefits for the selected plan.

The following table shows the effect on project feasibility considering the use of all of reported, or none of reported wages and profits which were obtained during flood damage interviews with the 134 firms in the project area. The table also shows the results of the analysis which was adopted for use in the determination of project justification. That analysis basically considered a portion of reported profit and wage losses from three firms whose losses were felt to have a very high probability of being National Economic Development losses. The values shown on the table considered growth in damages from 1986 through 1991 as outlined earlier in this appendix.

The table shows that the effect of using wage and profit losses in the development of NED benefits has only a small effect on project justification. It also illustrates that the selected 4-foot barrier raise is justified if none of reported wage and profit losses are counted toward project justification. The benefit-cost ratio using none of the reported wages and profits is 1.12.

Average annual equivalent damage, benefit and cost comparison of several assumed levels of NED wage and profit losses

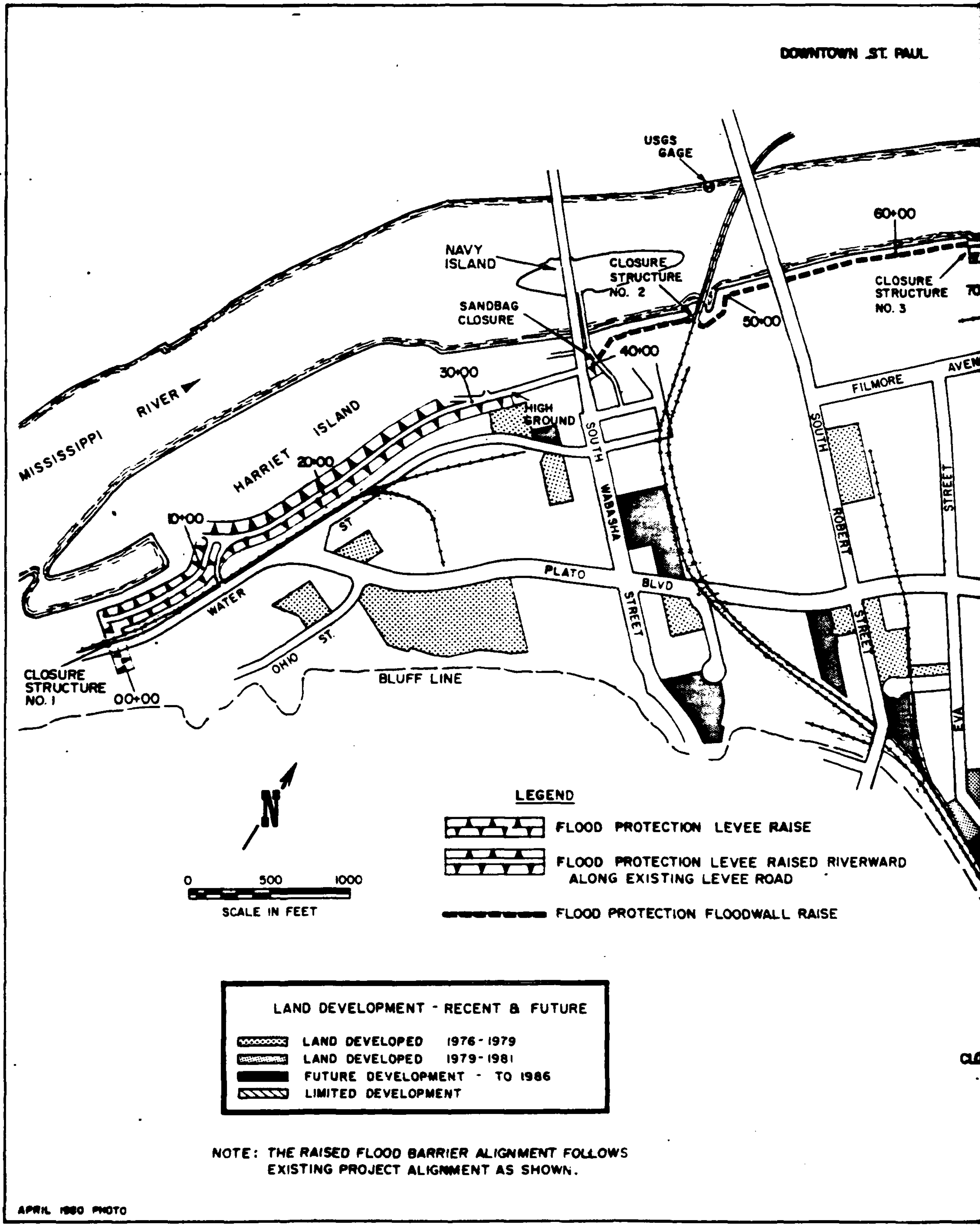
Item	None of reported [1,2] wages and profits used as NED losses ($1,000's)	All of reported [1,3] wages and profits used as NED losses ($1,000's)	Applicable [1,4] wages and profits used as NED losses ($1,000's)
Average annual equivalent damages	829.5	1030.4	938.2
Average annual equivalent benefits with 4-foot barrier raise	582.0	752.2	659.9
Average annual equivalent costs with 4-foot barrier raise	520.0	520.0	520.0
Average annual net benefits with 4-foot barrier raise	62.0	205.2	139.9
Benefit-cost ratio for 4-foot barrier raise	1.12	1.39	1.27

1 July 1981 prices, 7 3/8 percent discount rate.

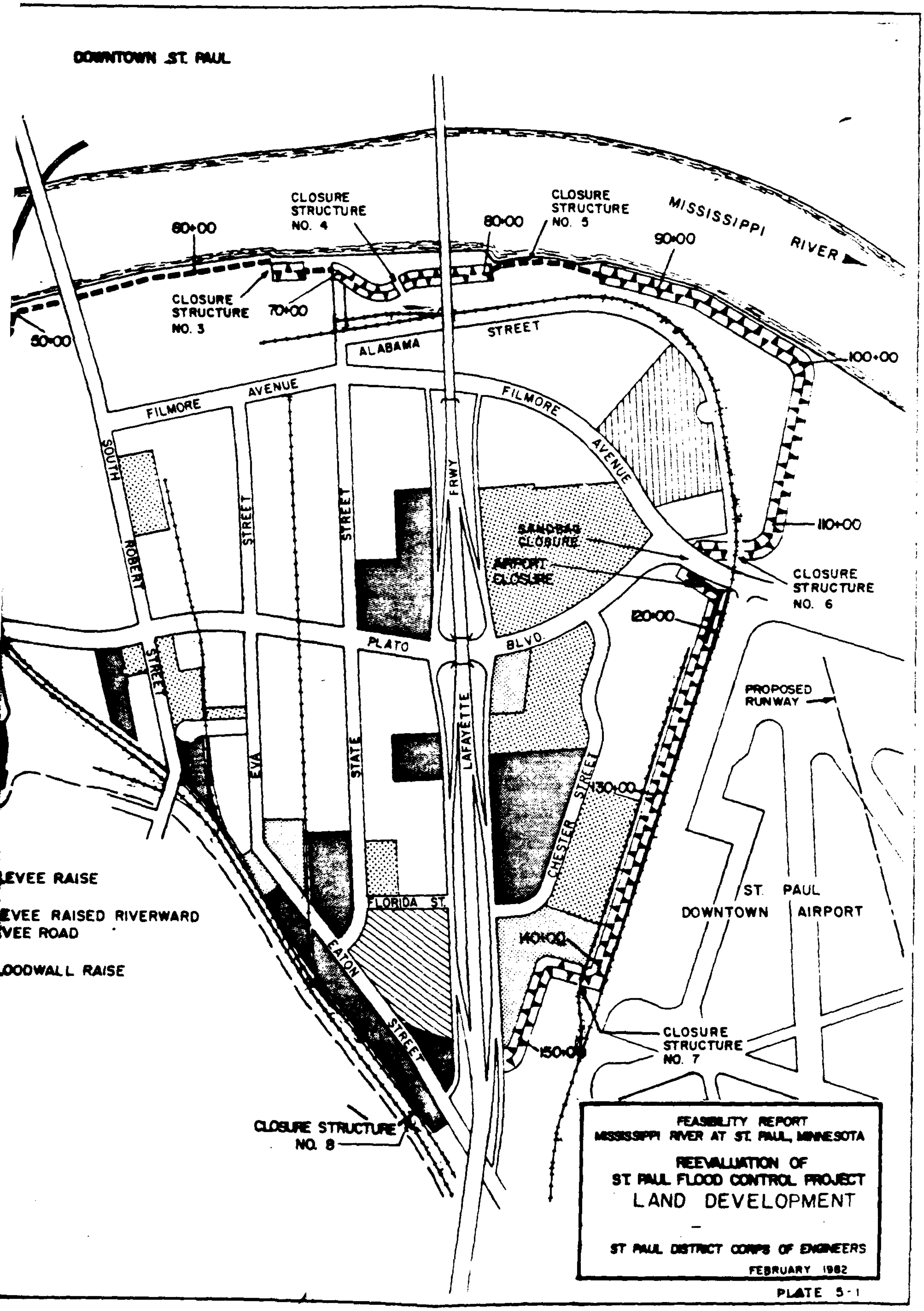
2 Considers that none of the profit and wage losses reported during flood damage surveys was applied to develop project benefits.

3 Considers all wages and profits from surveys used to develop project benefits.

4 Considers only a portion of wages and profits from three firms to develop project benefits. This method was used for project justification.



DOWNTOWN ST. PAUL
USGS GAGE
60+00
NAVY ISLAND
CLOSURE STRUCTURE NO. 2
SANDBAG CLOSURE
50+00
CLOSURE STRUCTURE NO. 3
40+00
30+00
HIGH GROUND
MISSISSIPPI RIVER
HARRIET ISLAND
20+00
10+00
FILMORE AVE
SOUTH WABASHA STREET
SOUTH ROBERT STREET
STREET
ST
PLATO BLVD
WATER
OHIO ST.
EVA
BLUFF LINE
CLOSURE STRUCTURE NO. 1
00+00
N
0 500 1000
SCALE IN FEET
LEGEND
FLOOD PROTECTION LEVEE RAISE
FLOOD PROTECTION LEVEE RAISED RIVERWARD ALONG EXISTING LEVEE ROAD
FLOOD PROTECTION FLOODWALL RAISE
LAND DEVELOPMENT - RECENT & FUTURE
LAND DEVELOPED 1976-1979
LAND DEVELOPED 1979-1981
FUTURE DEVELOPMENT - TO 1986
LIMITED DEVELOPMENT
NOTE: THE RAISED FLOOD BARRIER ALIGNMENT FOLLOWS EXISTING PROJECT ALIGNMENT AS SHOWN.
APRIL 1980 PHOTO


DOWNTOWN ST. PAUL
MISSISSIPPI RIVER
CLOSURE STRUCTURE NO. 3
CLOSURE STRUCTURE NO. 4
CLOSURE STRUCTURE NO. 5
CLOSURE STRUCTURE NO. 6
CLOSURE STRUCTURE NO. 7
CLOSURE STRUCTURE NO. 8
50+00
60+00
70+00
80+00
90+00
100+00
110+00
120+00
130+00
140+00
150+00
ALABAMA STREET
FILMORE AVENUE
SOUTH ROBERT STREET
EVA STREET
STATE STREET
LAFAYETTE FRWY
PLATO BLVD.
CHESTER STREET
FLORIDA ST.
EATON STREET
SANDBAG CLOSURE
AIRPORT CLOSURE
PROPOSED RUNWAY
ST. PAUL DOWNTOWN AIRPORT
LEVEE RAISE
LEVEE RAISED RIVERWARD
LEVEE ROAD
FLOODWALL RAISE
FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT
LAND DEVELOPMENT
ST. PAUL DISTRICT CORPS OF ENGINEERS
FEBRUARY 1982
PLATE 5-1

RESIDENTIAL, COMMERCIAL & INDUSTRIAL DAMAGE	Sub-Reach No.	Page of Pages	
NAME	Address		
CITY OR TOWN	Date	By	
TYPE OF BUSINESS: G-F-P	Building, Type, Construction & Size		

	FLOOD DAMAGES			
	Actual With Flood Fight	Without Flood Fight	+ Feet	- Feet
W. S. ELEV.				
ELEVATION AT 1st FLOOR LEVEL				
DEPTH OF FLOOD WATER OVER 1st FLOOR				
DAMAGE TO ROADS, BRIDGES, STREETS & GROUNDS				
DAMAGE TO RAILROAD TRACKS & BEDS				
COST OF REROUTING TRAINS, TRUCKS, CARS OR BUSSES				
DAMAGE TO BUILDINGS:				
1. FLOORS				
2. WALLS				
3. WINDOWS				
4. FOUNDATION				
DAMAGE TO EQUIPMENT:				
5. ELEVATORS & ESCALATORS				
6. AIR CONDITIONING SYSTEM				
7. HEATING PLANT, BOILERS				
8. COMPRESSORS				
9. REFRIGERATION UNITS				
10. FOUNDRY FURNACE				
11. PATTERNS				
12. MACHINE TOOLS				
13. WELDING EQUIPMENT				
14. HAND TOOLS - PAINT EQUIPMENT				
15. OTHER				
FURNITURE & ACCESSORIES:				
16. FURNITURE				
17. FLOOR COVERINGS				
18. DISPLAY CASES, COUNTER & BINS				
19. RECORDS & PERSONAL EFFECTS				
SEWER SYSTEM:				
WATER SUPPLY SYSTEM:				
POWER & LIGHT SYSTEM:				
20. COMMUNICATION SYSTEM				
21. SWITCHBOARDS				
22. TRANSFORMERS				
23. GENERATORS				
24. ENGINES				
25. WIRING				
MERCHANDISE:				
COST OF FLOOD FIGHTING & REMOVAL OF DEBRIS				
COST OF EVACUATION				
COST OF CLEANUP & REHABILITATION				
LOSS OF WAGES				
LOSS OF PROFITS DUE TO INTERRUPTION OF BUSINESS:				
TOTALS				

REMARKS :

PLATE 5-2

NCS Form 52 (OT)
(Rev. 24 Nov 65)

St. Paul 216 - Growth Survey Questions

A. Current Conditions

1. What changes from the previously reported damages have occurred and what are the current (April 1981) damages?

2. What are the current damages if no evacuation could be done?

3. How long would evacuation take?

4. Would you evacuate if the river stage forecast were for a crest 1 foot below the top of the levee/floodwall?

5. What is the past growth of damageable property?

B. Future Conditions

1. How long is your company's planning horizon?

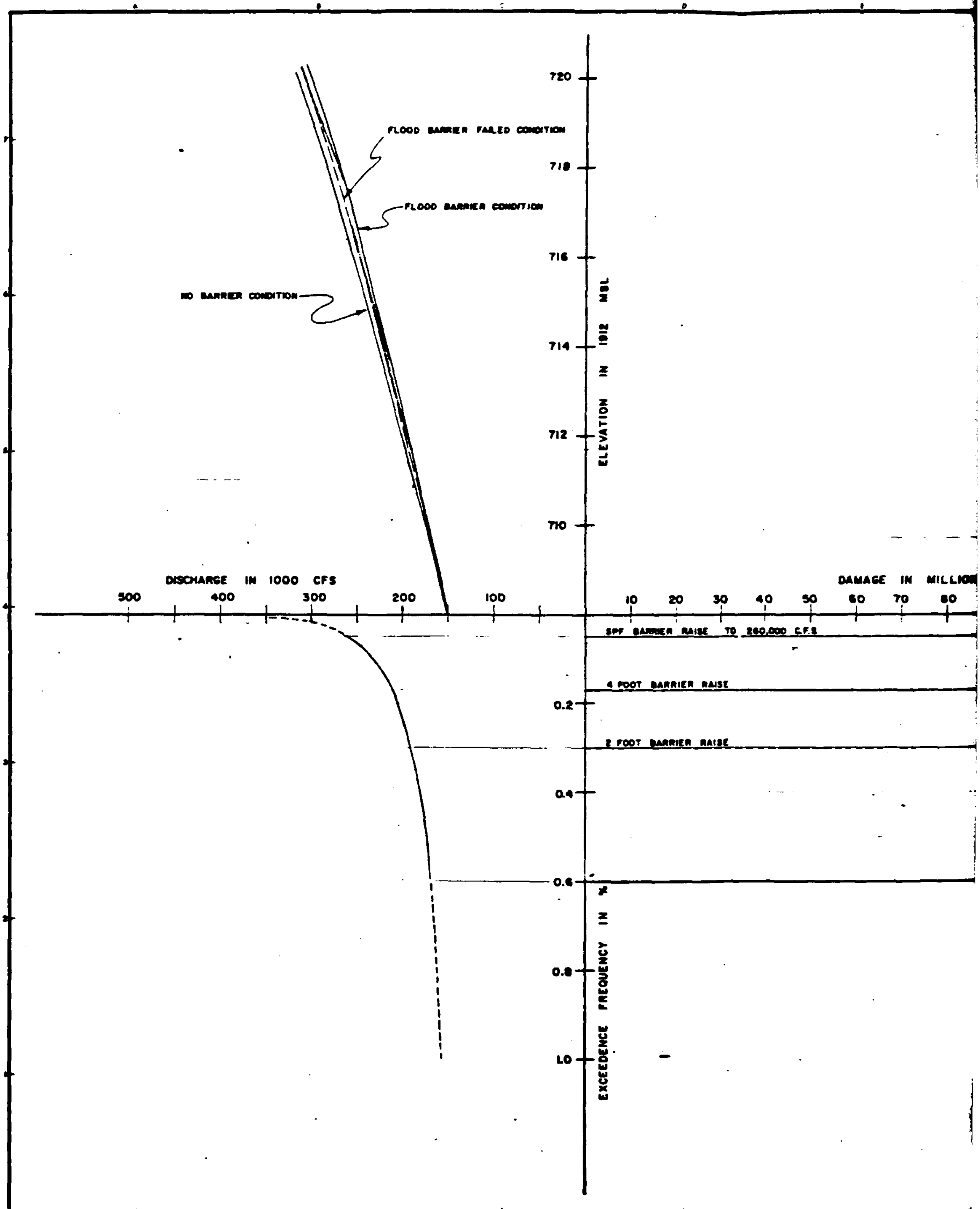
2. What change to damageable property in existing floor space is foreseen?

3. Are any large changes in employment foreseen?

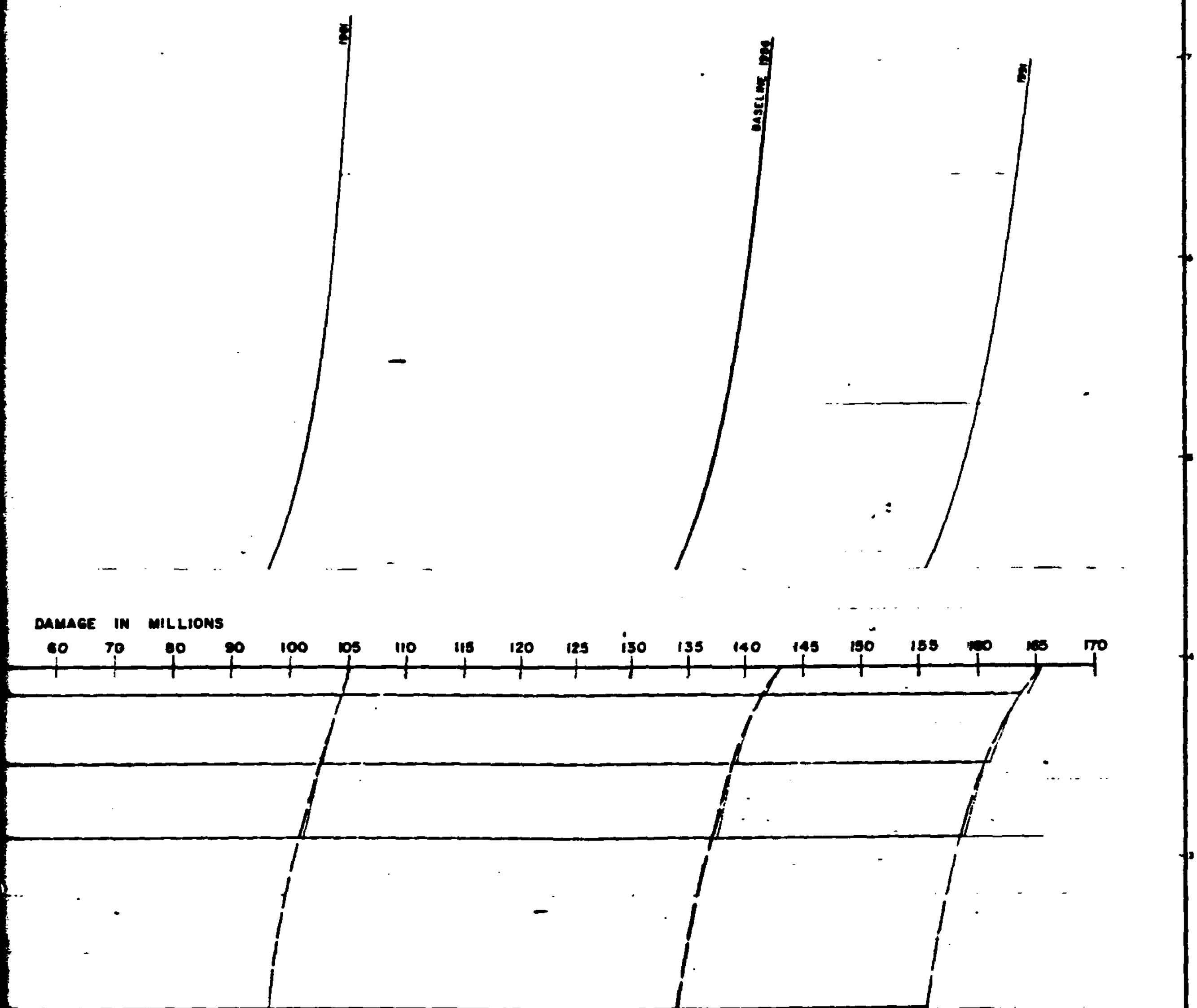
4. What additions are planned and what damageable property will be in additions?

5. Would you evacuate if the prediction was for levee overtop and how long would evacuation take under future conditions?

6. What would be damages without evacuation under future conditions?



FLOOD BARRIER FAILED CONDITION
FLOOD BARRIER CONDITION
NO BARRIER CONDITION
720
718
716
714
712
710
ELEVATION IN 1912 MSL
DISCHARGE IN 1000 CFS
500
400
300
200
100
DAMAGE IN MILLION
10
20
30
40
50
60
70
80
SPF BARRIER RAISE TO 260,000 C.F.S
4 FOOT BARRIER RAISE
2 FOOT BARRIER RAISE
0.2
0.4
0.6
0.8
1.0
EXCEEDENCE FREQUENCY IN %



AVERAGE ANNUAL DAMAGES

EXISTING CONDITIONS	1981	1986	1991
	604,800	823,100	994,800

AVERAGE ANNUAL BENEFITS

PROJECT DESIGN CONDITIONS	1981	1986	1991
2 FT BARRIER	294,600	405,700	470,300
4 FT BARRIER	427,300	585,200	677,000
SPF BARRIER	552,300	753,800	872,300

JULY 1981 PRICES

SAFETY PAYS

ST. PAUL FLOOD CONTROL PROJECT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA

QUADRIGRAPH

MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA

SUBMITTED BY:

APPROVED:

DATE: FEBRUARY [illegible]

ST. PAUL, MINNESOTA DISTRICT

DRAWING NUMBER

SHEET OF

FEASIBILITY REPORT

MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA

REEVALUATION OF

ST. PAUL FLOOD CONTROL PROJECT

HYDROLOGIC ANALYSIS

APPENDIX 6

ST. PAUL DISTRICT, CORPS OF ENGINEERS
September 1981

TABLE OF CONTENTS

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BASIN DESCRIPTION

The drainage area of the Mississippi River basin at St. Paul is 36,800 square miles - 44 percent of the State of Minnesota. The Mississippi River flows for about 495 miles from Lake Itasca to St. Paul, with an estimated travel time of about 20 days. Current velocities for low and high flows are 0.27 and 4.69 feet per second, respectively. The St. Paul flood control project is located on the Mississippi River immediately opposite the downtown area of St. Paul, Minnesota.

HISTORICAL FLOODS

Important factors affecting flood flows on the Mississippi River at St. Paul include the amount and distribution of precipitation, infiltration loss rates, and synchronization of flows from major tributaries. Summer floods are produced by storms of long duration distributed over a large area or by a series of large storms over the basin. Spring floods are affected by many factors such as the accumulation of snow, depth of frost in the ground, and extent and rapidity of thawing throughout the basin. Rainfall may add to the spring flood flows, but heavy rainstorms are rare during the snowmelt period. Damaging floods do not occur during the winter because the cold climate does not permit sufficient snowmelt.

Most of the large floods have occurred in the spring, principally during April, but major floods have occurred occasionally during other months. Seven of the ten largest floods of record were primarily the result of snowmelt and had peaks in March or April, but summer rains have caused a larger portion of the smaller floods. The largest known summer flood, that of July 1867, was the seventh largest of all known floods.

The record flood of 1965 resulted from a culmination of many factors. Rains late in the previous fall were followed by freezing temperatures, resulting in impervious surface conditions. Deep frost penetration during the winter, normal snowfalls followed by rains which froze and remained suspended in the snowpack, and simultaneous rain and snowmelt during the first week in April added to the problem. The Mississippi River crest of 91,000 cfs coincided with a Minnesota River flow of 80,000 cfs resulting in the record 171,000 cfs discharge at St. Paul. The maximum gage height was 26.01 feet. The 1965 flood hydrograph is presented on Plate 6-4.

The 1969 flood was the second largest of record. Heavy rains occurred from August through October 1968, causing unusual flooding in many areas, particularly along the Minnesota River above the Twin Cities. The ground stayed wet through the normally dry month of November and again the soil froze into an impervious surface. Snowfall that winter was record to near-record over most of the north central United States, and the snowpack built up as the temperature stayed below normal. Normally, occasional thaws create a crust on the fallen snow. However, this did not take place, and the entire winter's snowfall was subject to continual drifting. Thus, large amounts of drifting snow tended to concentrate in low areas such as the valleys of tributary streams. By 14 March, the water content of the accumulated snow ranged from 4 inches at St. Paul to 8 inches in the headwaters. Cold weather nearly halted snowmelt runoff during the latter part of March, allowing many streams to drop below flood stage. However, a rainfall of 1 to 2 inches in central and western Minnesota during 7-9 April combined with snowmelt already running off in early April to create abnormally high flood crests during 9-14 April. At St. Paul, the flood crested at 24.52 feet with a discharge of 156,000 cfs. The 1969 flood hydrograph is presented on plate 6-5.

The high water of 1952 was largely caused by melting snow and a small amount of precipitation during the breakup period. Discharges on the Mississippi River above St. Paul and on the Minnesota River near

its mouth were the greatest of record. The estimated peak discharge at St. Paul was 125,000 cfs. the third largest recorded flood. Flood stage was exceeded on 9 April, and the peak, 22.0 feet, was reached on 16 April. The recession was slow, and the level did not fall below flood stage until 1 May.

The following table shows the peaks and gage heights of the largest known floods at St. Paul.

Largest known floods - Mississippi River at St. Paul, Minnesota

Date	Peak (cfs)	Gage height(1) (feet)
1965	171,000	26.01
1969	156,000	24.52
1952	125,000	22.02
1881	107,000	19.7
1870	104,700	19.4
1951	92,800	18.8
1867	92,000	18.6
1897	86,200	18.0
1875	86,200	18.0
1867	80,800	-
1957	78,400	16.7
1975	78,300	-
1916	73,500	-
1908	73,000	16.8
1873	71,800	16.4
1869	69,400	16.1
1917	68,600	16.2
1880	62,200	15.2
1905	59,800	14.8
1893	58,800	14.7
1943	58,200	14.5
1944	56,900	14.3
1962	56,400	-

(1) The datum of the gage is 686.32 feet above mean sea level, 1929 adjustment.

ASSESSMENT OF AVAILABLE DATA

To make the data on St. Paul as complete as possible, peak discharges for the years 1867 through 1891 were estimated from known gage heights, except for the years 1870 and 1871. For these years, peak stages were estimated on the basis of newspaper accounts and miscellaneous discharge observations made during the period. Instantaneous peak flows were obtained from U.S. Geological Survey records or estimated from mean daily discharges or highest observed gage heights. Main stem Mississippi River gages upstream of St. Paul are located near Grand Rapids, Aitkin, Royalton, and Anoka, Minnesota. Minnesota River gages are located near Ortonville, Montevideo, New Ulm, Lac qui Parle, Mankato, and Jordan (replacing Carver), Minnesota.

FLOOD FREQUENCIES

The discharge-frequency curve (see plate 1-1) for the Mississippi River at St. Paul was developed in accordance with the provisions of Bulletin 17 of the Water Resources Council's "Guidelines for Determining Flood Flow Frequency," 1976. The curve was based on data compiled during the 106 years from 1867 through 1972. Development of these data required coordination with several agencies including St. Paul District, Rock Island District, St. Louis District, Upper Mississippi River Basin Commission, U.S. Geological Survey, and the States where the stations are located. Previous discharge-frequency derivations were updated, and the entire reach from St. Paul to Alton, Illinois, was analyzed. The figures for St. Paul were reanalyzed using Water Resources Council Bulletin 17A (revised June 1977) with 6 additional years of record. The following table shows the adopted statistics on which the curve was based. Land use changes for the drainage area above St. Paul are not expected to significantly change the frequency curve. Therefore, no modification for future conditions has been made to Plate 6-1.

Station data						
			Adopted statistics			100-year
Station	Years of record	Equivalent years(1)	Mean	Standard deviation	Skew coefficient	(probability plotting) frequency flow (cfs)
St. Paul, Minnesota	106	---	4.57	0.274	-0.2	150,000
Prescott, Wisconsin	83	103	4.74	0.244	-0.1	200,000
Winona, Minnesota	95	99	4.93	0.194	0	246,000
La Crosse, Wisconsin	92	100	4.96	0.186	0	253,000
McGregor, Iowa	36	88	4.99	0.175	0	256,000
Dubuque, Iowa	103	---	5.092	0.16	-0.2	281,000
Clinton, Iowa	102	---	5.113	0.1586	-0.2	295,000
Keokuk, Iowa	98	125	5.248	0.1515	-0.2	351,000
Hannibal, Missouri	97	176	5.304	0.1498	-0.2	374,000
Louisiana, Missouri	97	125	5.315	0.1493	-0.2	410,000
Alton, Illinois	96	191	5.390	0.1484	-0.1	510,000

(1) Equivalent years of record are statistical estimates based on longer records at nearby stations.

STANDARD PROJECT FLOOD

Derivation of a standard project flood for the Mississippi River at St. Paul by means of a single unit hydrograph for the total drainage area of 36,800 square miles would give results of questionable value. To derive unit hydrographs for several component areas and apply rainfall excess to these unit hydrographs for a storm distributed over this total drainage area together with accompanying flood routing would require an exorbitant amount of computation and would be subject to many assumptions. Furthermore, the final answer would be of questionable value. The standard project flood for the Mississippi River at St. Paul, reflecting the 1965 record flood data, was derived by a method similar to that used by the Chief of Engineers to compare the standard project flood for St. Paul with those at other locations on the lower Minnesota and Upper Mississippi Rivers. In this method, the maximum discharge of record was plotted against drainage area on logarithmic paper for each gaging station on the Minnesota and Mississippi Rivers from Mankato, Minnesota, to St. Louis, Missouri. The discharges and drainage areas are shown in the following table.

Maximum discharges of record and 200-year frequency discharge - Mississippi River

Location	Drainage area (square miles)	Maximum recorded flow (cfs)	Date	200-year frequency flow (cfs)
Minnesota River at Mankato, Minn.	14,900	94,100	10 April 1965	131,000
Minnesota River near Carver, Minn.	16,200	117,000	11 April 1965	137,000
Mississippi River at St. Paul, Minn.	36,800	171,000	16 April 1965	172,000
Mississippi River at Prescott, Wis.	44,800	228,000	18 April 1965	228,000
Mississippi River at Winona, Minn,	59,200	268,000	19 April 1965	273,000
Mississippi River at La Crosse, Wis.	62,800	278,000	22 April 1965	281,000
Mississippi River at McGregor, Iowa	67,500	276,000	24 April 1965	282,000
Mississippi River at Guttenberg, Iowa	79,400	308,000	24 April 1965	352,000
Mississippi River at Dubuque, Iowa	81,600	304,000	26 April 1965	304,000
Mississippi River at Clinton, Iowa	85,600	307,000	28 April 1965	321,000
Mississippi River at Keokuk, Iowa	119,000	360,000(1) 327,000 381,000	6 June 1851 1 May 1965 24 April 1973	372,000
Mississippi River at Alton, Ill.	171,500	437,000(2) 535,000	24 May 1943 28 April 1973	555,000
Mississippi River at St. Louis, Mo.	701,000	1,300,000(3)	27 June 1844	1,125,000

(1) Estimated flow published by U.S. Geological Survey.
(2) Includes 90,000 cfs floodwater overflow from Missouri River.
(3) Estimated flow published by U.S. Geological Survey and computed by Corps of Engineers.

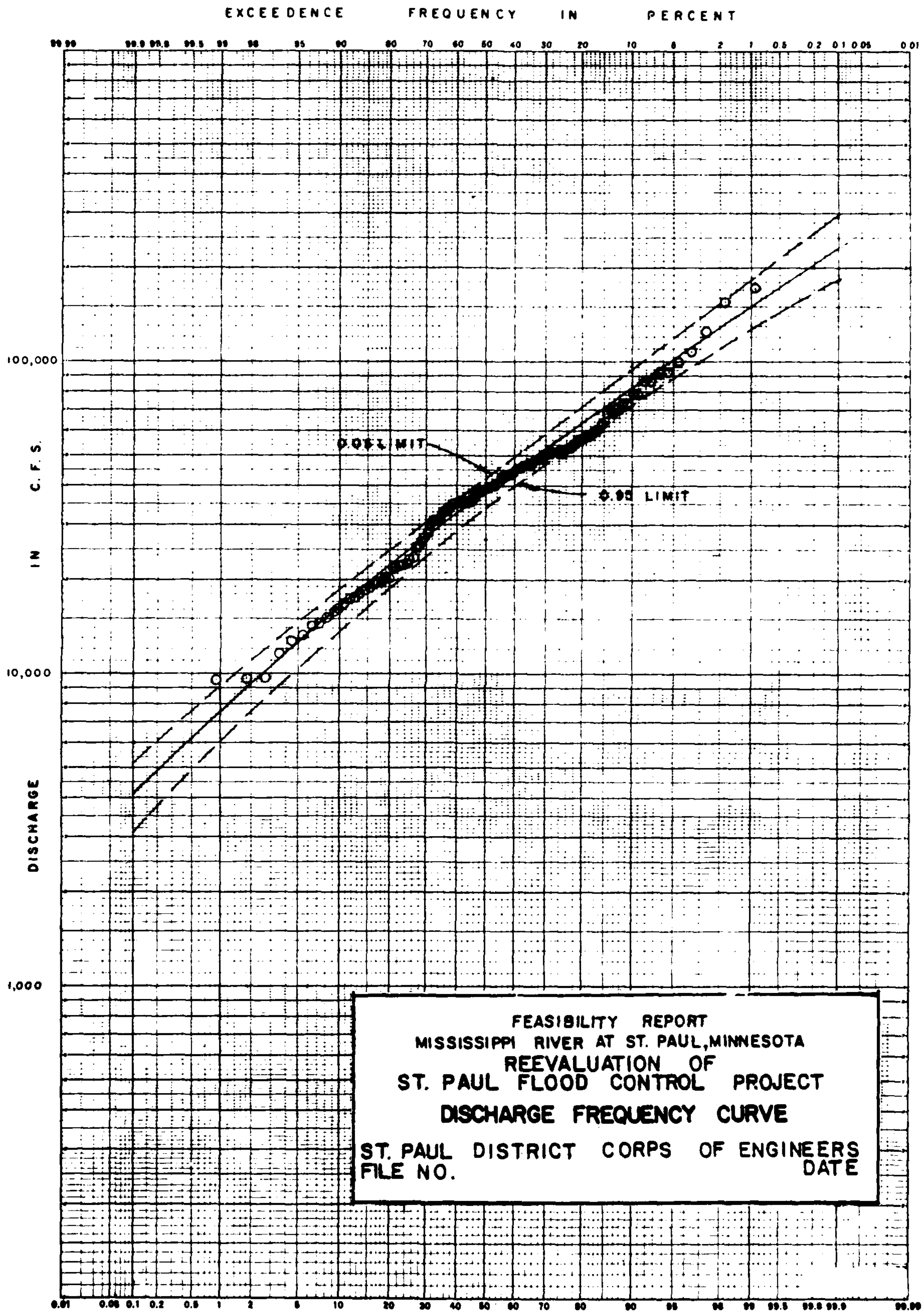
A straight line drawn through the points plotted for Prescott, Wisconsin, and St. Louis results in the maximum enveloping line shown on Plate 1-2. The discharge-frequency relationships shown in the previous table were obtained from an October 1977 report of the Upper Mississippi River Basin Commission entitled "Flow Frequency Estimates, Mississippi River, Mile 202 to Mile 840," using techniques described in the Water Resources Council Bulletin 17. The 200-year discharges for the Minnesota River at Mankato and Carver, Minnesota, were obtained from previous studies made in the St. Paul District. The 200-year discharge for St. Louis was obtained from the St. Louis District. Although the St. Louis District does not have an approved standard project flood for any Mississippi River gaging station, a preliminary standard project flood hydrograph (crest discharge of 1,650,000 cfs) was derived for the St. Louis gage by St. Louis District. This flood was tested in the Mississippi River basin model under two conditions: alternative 1 considered 825,000 cfs from the Missouri River and 825,000 cfs from the Upper Mississippi River, and alternative 2 considered 900,000 cfs from the Missouri River and 750,000 cfs from the Upper Mississippi River. Flows of 750,000 cfs and 825,000 cfs for the Upper Mississippi River contribution to the St. Louis preliminary standard project flood were plotted as approximations of the standard project flood at Alton, Illinois, gaging station.

Detailed studies conducted in the St. Paul District indicate that the spring standard project flood for the Minnesota River at Mankato would be 155,000 cfs. (See "Report on Probable Maximum Floods and Standard Project Floods, Minnesota River Basin, Minnesota," by St. Paul District, January 1971.) The preliminary standard project flood peaks for Alton and St. Louis and the standard project flood for Mankato were plotted on the same grid as the maximum discharges of record. A line drawn parallel to the maximum discharge of record envelope line and through the 155,000 cfs standard project flood point at Mankato represents

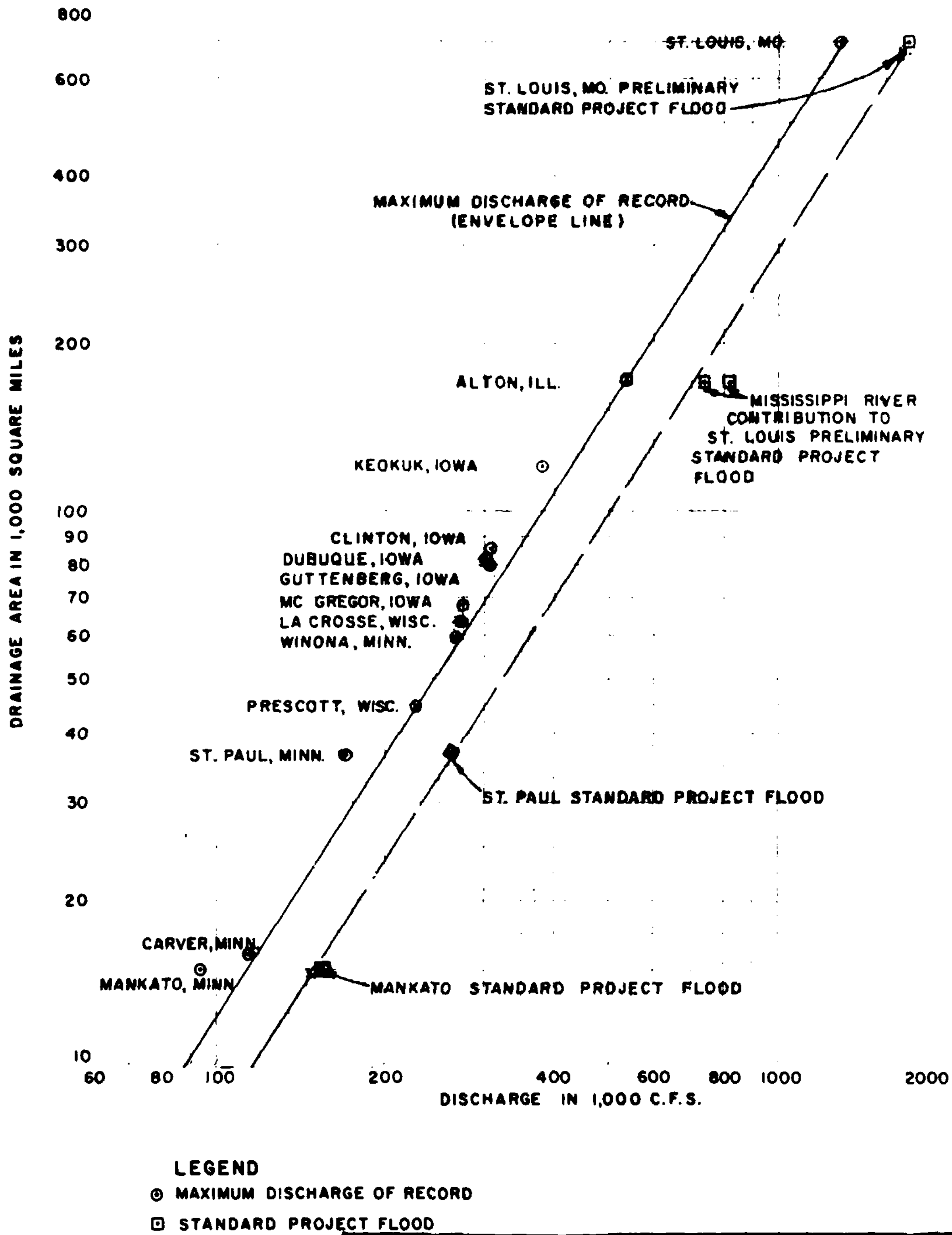
a close fit to the plotted standard project flood points. This line was used to establish the standard project flood at St. Paul shown on plate 1-3. A slight change in position or slope of the standard project flood line would not appreciably affect the flood magnitude at St. Paul. The standard project flood peak for the Mississippi River at St. Paul, with a drainage area of 36,800 square miles, is 260,000 cfs.

PROJECT IMPACT

The impact of the project improvements on areas upstream and downstream is negligible because the 448 acres in the protected area has an estimated storage capacity of only 1,500 acre-feet. This capacity is very small compared with the volume of the standard project flood at its peak - about 4.5 million acre-feet. Therefore, the project would not be expected to attenuate the standard project flood because of storage effects, and would not have an effect on the peak flow.



FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT
DISCHARGE FREQUENCY CURVE
ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE NO. DATE

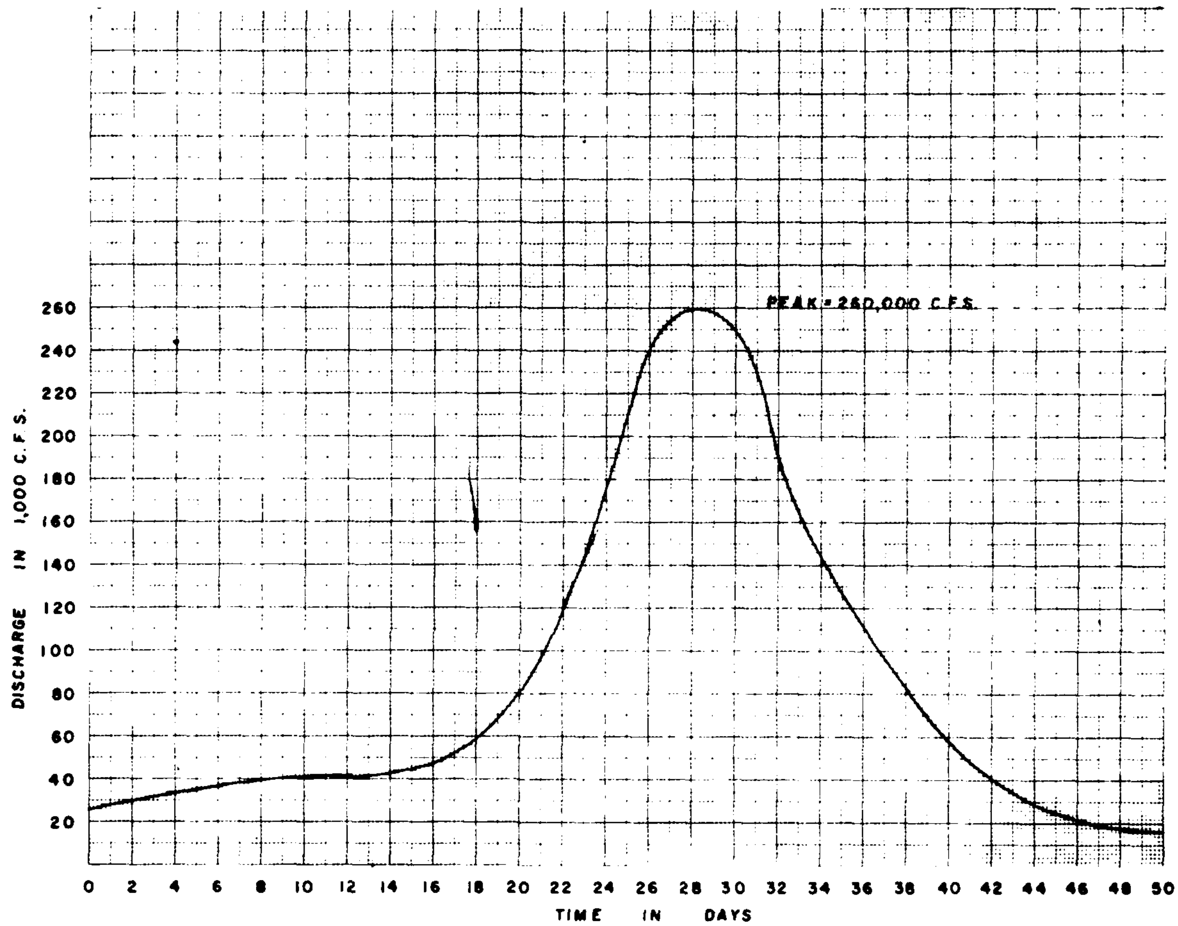


FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT

DERIVATION OF STANDARD PROJECT FLOOD

ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE NO. DATE

Plate 6-2

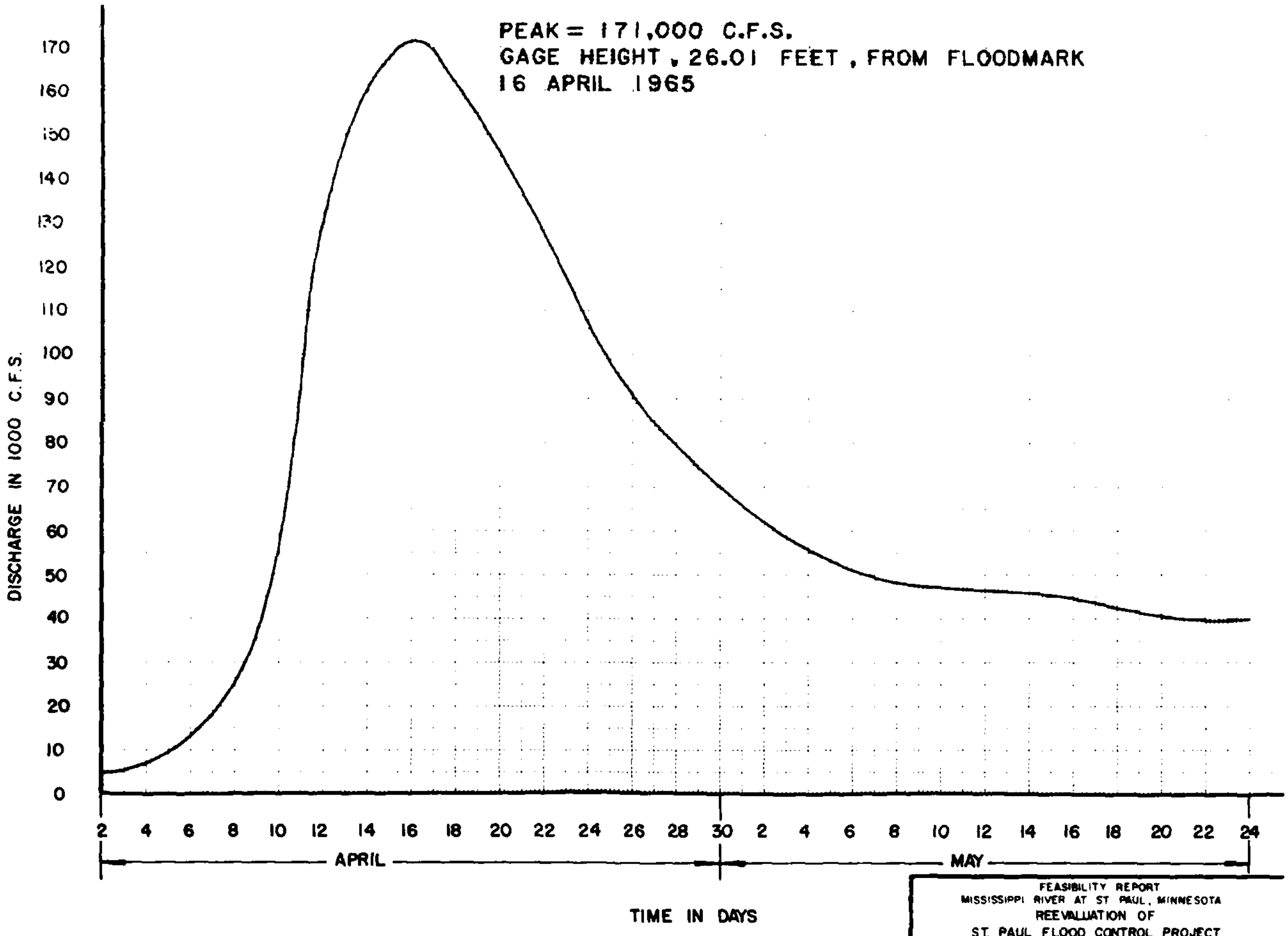


FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT

STANDARD PROJECT FLOOD HYDROGRAPH

ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE NO. DATE

Plate 6-3

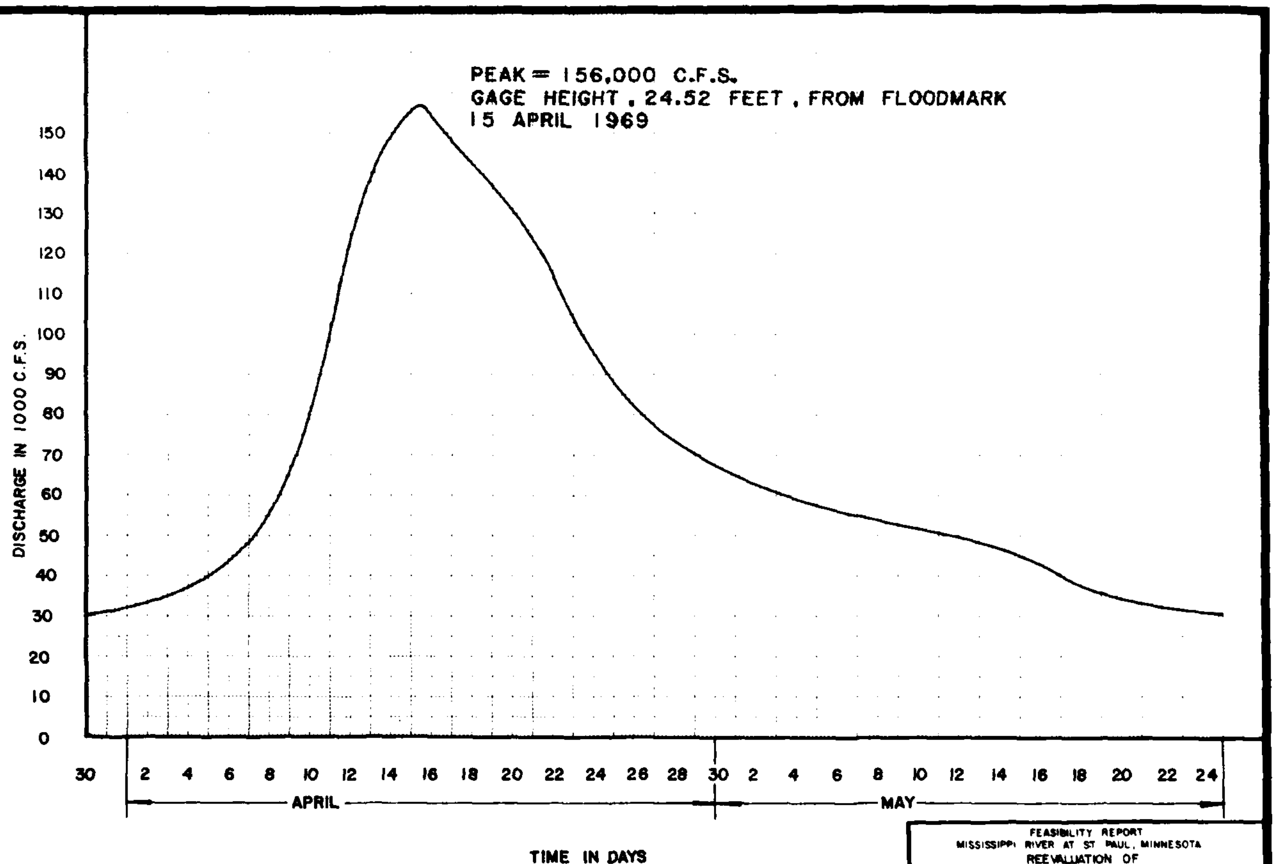


FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT

SPRING 1965 FLOOD HYDROGRAPH
(FLOOD OF RECORD)

ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE No. DATE:

PLATE 6-4

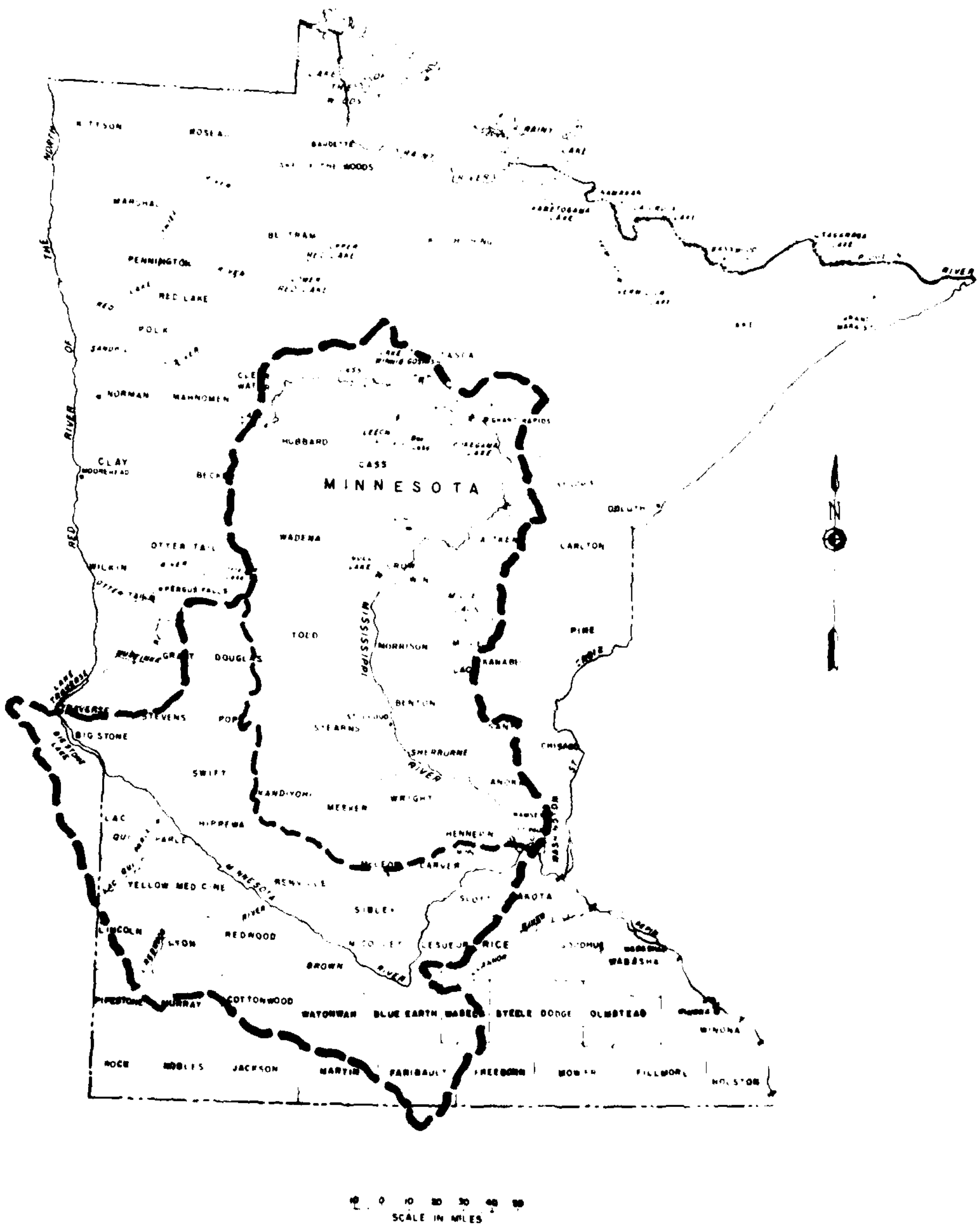


FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT

SPRING 1969 FLOOD HYDROGRAPH

ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE No. DATE:

PLATE 6-5



FEASIBILITY REPORT
MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA
REEVALUATION OF
ST. PAUL FLOOD CONTROL PROJECT

BASIN MAP

ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE NO. DATE

PLATE 6 6

FEASIBILITY REPORT

MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA

REEVALUATION OF

ST. PAUL FLOOD CONTROL PROJECT

CULTURAL RESOURCES

APPENDIX 7

ST. PAUL DISTRICT, CORPS OF ENGINEERS

September 1981

Form No 10 300 (Rev 10 74)

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

FOR NPS USE ONLY
RECEIVED
DATE ENTERED

.TIONAL REGISTER OF HISTORIC PLACES INVENTORY -- NOMINATION FORM

SEE INSTRUCTIONS IN *HOW TO COMPLETE NATIONAL REGISTER FORMS*
TYPE ALL ENTRIES -- COMPLETE APPLICABLE SECTIONS

1 NAME

HISTORIC
MINNESOTA BOAT CLUB BOATHOUSE ON RASPBERRY ISLAND

AND/OR COMMON
MINNESOTA BOAT CLUB BOATHOUSE ON NAVY ISLAND

2 LOCATION

STREET & NUMBER
1 SOUTH WABASHA STREET — __NOT FOR PUBLICATION

CITY, TOWN
ST. PAUL — __ VICINITY OF — CONGRESSIONAL DISTRICT 4 th

STATE MINNESOTA — CODE — COUNTY — CODE

3 CLASSIFICATION

CATEGORY	OWNERSHIP	STATUS	PRESENT USE	
__DISTRICT	__PUBLIC	X OCCUPIED	__AGRICULTURE	__MUSEUM
__BUILDING(S)	X PRIVATE	__UNOCCUPIED	__COMMERCIAL	__PARK
X STRUCTURE	__BOTH	__WORK IN PROGRESS	X EDUCATIONAL	__PRIVATE RESIDENCE
X SITE	**PUBLIC ACQUISITION**	**ACCESSIBLE**	X ENTERTAINMENT	__RELIGIOUS
__OBJECT	__IN PROCESS	__YES: RESTRICTED	__GOVERNMENT	__SCIENTIFIC
	__BEING CONSIDERED	X YES: UNRESTRICTED	__INDUSTRIAL	__TRANSPORTATION
		__NO	__MILITARY	X OTHER athletic

4 OWNER OF PROPERTY

NAME
MINNESOTA BOAT CLUB

STREET & NUMBER
1 SOUTH WABASHA STREET

CITY, TOWN
ST. PAUL — __ VICINITY OF — STATE MINNESOTA 55101

5 LOCATION OF LEGAL DESCRIPTION

COURTHOUSE
REGISTRY OF DEEDS, ETC. RAMSEY COUNTY COURT HOUSE

STREET & NUMBER
15 WEST KELLOGG

CITY, TOWN
ST. PAUL — STATE MINNESOTA 55101

6 REPRESENTATION IN EXISTING SURVEYS

TITLE
NONE

DATE
__FEDERAL __STATE __COUNTY __LOCAL

DEPOSITORY FOR
SURVEY RECORDS

CITY, TOWN — STATE

7 DESCRIPTION

CONDITION		CHECK ONE	CHECK ONE
__EXCELLENT	X DETERIORATED	__UNALTERED	X ORIGINAL SITE
X GOOD	__RUINS	X ALTERED	__MOVED DATE______
X FAIR	__UNEXPOSED		

DESCRIBE THE PRESENT AND ORIGINAL (IF KNOWN) PHYSICAL APPEARANCE

A. THE BUILDING

The Minnesota Boat Club boathouse on Navy Island (formerly Raspberry Island) overlooking the Mississippi River and a developing downtown St. Paul is the same building that was constructed in 1910. To this day, the building rates as one of the finest of its kind in North America.

The Club's first quarters was a floating boathouse anchored at the foot of Robert Street on the Mississippi River. This crude floating structure was first occupied in 1870, the same year in which the Club was organized. In 1885 a new two-story wooden structure was erected on Raspberry Island (now Navy Island) and served as a clubhouse until it was replaced by the present building in 1910. The 1885 boathouse, constructed by J. R. Rood at a cost of $2,000, measured 36 by 75 by 40 feet in height. Additions were constructed in 1886 and 1889.

The present building was designed by H. G. Carsley of St. Paul and constructed by George J. Grant Construction Company, also of St. Paul. The boathouse, estimated to cost $26,000, was considered to be the best rowing facility in the nation. It is assumed that building materials were transported to the island by barge or hauled overland through a dry inner-river bed, common to low water periods. No one is sure.

The present building, of Spanish design, consists of two stories and a hip roof with 3-foot eaves. The structure measures 67 feet wide by 86 feet long and 23 feet to the eaves. The footings (2 by 7 feet), first and second floor bases (8-inch), and 28 16-inch diameter columns supporting the second floor are all of steel reinforced concrete. The use of steel reinforced concrete was very novel at the time of construction.

The first and second floor walls are constructed of tile bricks (10-inch). Damage to portions of the east and south first floor walls during the 1965 flood necessitated replacement of this brick with concrete block (12-inch).

The ground floor serves as a storage area for rowing shells and equipment, a maintenance area for damaged equipment and a men's and women's locker room. A concrete block wall (8-inch) separates the locker rooms from the storage and maintenance area. The locker room contains lockers for men and women, showers for men, and a bathroom shared by both. A large obsolete steam boiler used to heat the building is also located in the locker room area. The storage area contains rowing shells, oars and other equipment used in rowing. A wrought iron spiral staircase (5-foot diameter) leads from the storage area to the second floor.

Five arched double doors (8 by 10 feet and 3 inches thick) allow access of rowing shells to floating docks on the Mississippi River. The doors are constructed of Douglas fir and are supported by wrought iron strap hinges (4 feet by 4 inches by ¼ inch) firmly bolted in place.

A wooden (fir) stair[illegible] gives access to the second floor [illegible], which served as a meeting, dining, and recreation cente[illegible] [illegible]

DESCRIBE THE PRESENT AND ORIGINAL(IF KNOWN)PHYSICAL APPEARANCE
(CONTINUED)

Since that time the area has been rented for use as a bar lounge to finance the Club's rowing activities and to help pay for new equipment.

The second floor has several unique features. The floor is constructed of oak (1¼- by 1-inch strips) and is in good condition. The walls (9'-6" high) support a vault type open beam ceiling whose fir beams (3 by 8 and 8 by 12 inches) slope upward to a height of 18 feet above the floor. The design and workmanship in the ceiling must be viewed to be truly appreciated.

On the north end of the second floor is a 10-foot square brick fireplace. The fireplace has a mantel (1-foot wide) 9 feet off the floor and a 5-foot wide hearth. The fireplace has been used since 1910 and adds greatly to the building's asthetics. An additional mantel (8 inches wide) also 9 feet off the floor lines the perimeter of the second floor. From 1910 to 1950 the mantel displayed trophies and plaques won by the Club.

Three sets of multi-pane dual opening glass doors and lites on the east side allow entrance to the second floor. Three identical openings provide access to an enclosed 10-foot wide balcony which extends the entire 86-foot length of the building. The balcony has seven openings (10 by 5 feet) which offer an excellent view of the Mississippi River and downtown St. Paul.

The second floor area has not been used since December 1976. The Minnesota Boat Club evicted the tenants because they caused damage to the second floor plumbing, heating, and electrical systems and their notoriety damaged the Club's reputation.

Since 1910 the building has remained basically unchanged. Alterations made since 1950 include:

1) Replacement of the tile brick roof with rolled asphalt (1950).

2) Removal of club owned trophies, plaques, pictures and other artifacts from the second floor (1950).

3) Removal of a 60-foot high flagpole and a 10-foot square flower garden at the flagpole base (1951).

4) Removal of kitchen facilities from the second floor (1955).

5) Removal of canopy over wood staircase leading to the second floor (1960).

6) Resurfacing of the fireplace with 2½ by 8-inch brick (1960).

7) Replacement of the tile brick first floor east and south walls with concrete blocks (1965).

8) Removal of the second floor spiral staircase landing railing (1965).

9) Ten-foot extension of the balcony eaves and placement of seven 10- by 5-foot windows in the balcony openings (1974).

DESCRIBE THE PRESENT AND ORIGINAL(IF KNOWN)PHYSICAL APPEARANCE (CONTINUED)

10) Removal of oak tables and benches, and a 30-foot oak bar top from second floor (1976).

11) Theft of the 10 balcony windows and all second floor lighting fixtures (1976).

12) Destruction of all second floor windows, glass doors and lites by vandals (1978).

The building was designed with the expectation that Raspberry Island would be periodically flooded. This accounts for the building's sturdy construction and the supporting columns which extend down to bedrock. The 1951, 1965, and 1969 floods each carried water into the building's first floor. The 1965 flood, worst in the area's history, was estimated to be a 150-year flood. Damage to the building was minor compared to the losses suffered by other structures in the area.

The 1965 flood washed away a portion of the upstream end of the island along with the bridge leading to the island and damaged the east and south first floor walls. A new bridge was soon constructed by the U.S. Government. All other materials and funds necessary for repairs were donated by civic-minded businesses and individuals. The work was performed by the Club members and an ambitious group of high school and college students. Approximately 5,000 cubic yards of waste concrete and stone was used to replace portions of the eroded island and approximately 2,500 concrete blocks were used to repair the damaged walls. An 8- by 12-foot area of the west wall was also replaced with concrete block.

The walls, floors, and columns are presently in good condition with no evidence of differential settlement. Structurally, the building stands stronger than ever.

Parts of the boathouse have unquestionably deteriorated in recent years. The leaky roof, rotting eaves and gutters must be replaced. The plumbing, heating and electrical systems are inadequate by current standards. The building is not insulated and it is vulnerable to fire and vandalism. Vandals have destroyed much of the building's glass and are assumed to be responsible for a fire which destroyed the second floor main electrical panel.

B. RESTORATION PROGRAM

The Minnesota Boat Club is developing plans to restore the entire building. The locker rooms will be remodeled using wasted space for lockers, showers, an exercise area, and an instruction area for men and women. The upstairs will be refurbished and made functional as a public restaurant, using a nautical theme. Displays of rowing trophies, plaques, pictures and many other artifacts will be located in the upstairs. The Club owned end of the island will be landscaped and a new flagpole and flower garden will be provided along with picnic tables and benches. Bleachers will be added to the island's extreme upper end so the many spectators can view the rowing regattas.

DESCRIBE THE PRESENT AND ORIGINAL(IF KNOWN)PHYSICAL APPEARANCE (CONTINUED)

The following is a list of necessary repairs:

1) Resurface rolled asphalt roofing with red tile.

2) Insulate ceiling.

3) Repair deteriorated eaves and gutters.

4) Replace all windows with double pane and storm sash windows.

5) Replace damaged doors.

6) Replace the plumbing, electrical, heating, and ventilation systems with equipment that meets State building codes.

7) Replace the exterior stucco finish with new stucco.

8) Repaint all interior areas.

9) Refinish oak floor.

10) Replace damaged docks and ramps.

C. SITE

The Minnesota Boat Club boathouse on Navy Island is in the center of an area rich with history and active with industry and recreation.

The island is located on the Mississippi River. A renewed downtown St. Paul borders the north bank and a mixed industrial and residential section of West St. Paul borders the south bank. The West St. Paul side includes Harriet Island Park and the Lilydale Marina where paddlewheel ferryboats still operate.

The area upstream of the island is used predominantly for recreation except for the Shepard Road commercial grain elevators. The adjacent Harriet Island Park and Lilydale Marina area provides an attractive setting for picnics, banquets, dancing, swimming, fishing, boating, water skiing, cross-country skiing, and St. Paul Winter Carnival treasure hunts. In the Irving Park National Historical District, across the river from Harriet Island Park, some of St. Paul's oldest and most lavish homes are being restored. Farther upriver are the Water Gate Park and Marina, the St. Paul Yacht Club and marina, several other parks, and riverfront bike and hiking trails.

Downstream from Raspberry Island and the Minnesota Boat Club, the river area is used mainly for industrial and commercial facilities which provide for the transport of grain, coal, oil and other commodities to and from St. Paul.

Navy Island is in the heart of the St. Paul-Mississippi River Corridor Plan. The plan, still in its preliminary draft stage, will develop a long-range guide for using the natural and cultural resources of the area, giving special attention to the area's recreation and education potential. Navy Island's Minnesota Boat Club will be an integral part of the plan.

8 SIGNIFICANCE

PERIOD	AREAS OF SIGNIFICANCE -- CHECK AND JUSTIFY BELOW			
_PREHISTORIC	_ARCHEOLOGY-PREHISTORIC	_COMMUNITY PLANNING	_LANDSCAPE ARCHITECTURE	_RELIGION
_1400-1499	_ARCHEOLOGY-HISTORIC	_CONSERVATION	_LAW	_SCIENCE
_1500-1599	_AGRICULTURE	_ECONOMICS	_LITERATURE	_SCULPTURE
_1600-1699	X ARCHITECTURE	X EDUCATION	_MILITARY	X SOCIAL/HUMANITARIAN
_1700-1799	_ART	_ENGINEERING	_MUSIC	_THEATER
_1800-1899	_COMMERCE	_EXPLORATION/SETTLEMENT	_PHILOSOPHY	_TRANSPORTATION
X 1900-	_COMMUNICATIONS	_INDUSTRY	_POLITICS/GOVERNMENT	X OTHER (SPECIFY) athletic
		_INVENTION		

SPECIFIC DATES

BUILDER/ARCHITECT GEORGE J. GRANT CONSTRUCTION COMPANY/H. G. CARSLEY

STATEMENT OF SIGNIFICANCE

The Minnesota Boat Club occupies an important place in the social and recreational history of St. Paul. The club was founded in March 1870 and has occupied the site on Raspberry Island continuously since that date. The Minnesota Boat Club is the oldest athletic organization in Minnesota. Its facilities were once considered the finest in the nation.

The Minnesota Boat Club was one of two charter members of the Minnesota and Winnipeg Rowing Association founded in 1885, the forerunner of the present North-western International Rowing Association (NWIRA) founded in 1915. The club has won the Sir Thomas Lipton Grand Aggregate trophy at the NWIRA regatta more times than any other club in the Association's history. The Club was instrumental in organizing rowing teams at the University of Minnesota, St. John's University, and the College of St. Thomas. It also organized the Twin Cities' high school rowing in the 1950's and sponsors an annual fall regatta exclusively for high school oarsmen.

The Minnesota Boat Club was strongest from 1890 to 1930, when it was a prominent social center in St. Paul. During this period, the Club popularized curling in the Twin Cities, building a curling rink adjacent to the tennis courts on the downstream end of the island in 1891. In the early 1900's the Club-sponsored tableaux and benefit concerts were popular among area residents. Throughout this period, the clubhouse was a well known night spot which had many dinners and dances. The Club's cherry and white uniforms were a regular feature, too, of the Winter Carnival parades, in which club members carried a rowing shell. The most spectacular of all club activities, however, were the semi-annual regattas. When rowing was at its peak - in 1915 there were 115 active rowers in the club-the river racecourse would be lined from start to finish with spectators.

During the two World Wars, club rolls declined drastically as members joined the armed services. In 1948, a U.S. Naval Reserve training center was constructed on the downstream side of the island, and Reservists regularly rowed with the club and participated in shell races. During the Second World War, the Club assisted the Coast Guard in patrolling the Mississippi River for possible sabotage.

The Club was founded as a center for the healthful sport of rowing, both morally and physically beneficial to members, young and old, who could participate vigorously or mildly in their sport. It continues to serve that purpose and is enjoying a resurgence of interest among young men and women of St. Paul who recognize both the historical and recreational significance of the club. The present membership is strongly interested in the restoration of their clubhouse. At present, the building is structurally sound and functionally very serviceable. But extensive internal repairs and some remodeling are necessary. Plans for such restoration are being made and an outline of repairs is included with this submission.

SIGNIFICANT FIGURES IN THE HISTORY OF THE MINNESOTA BOAT CLUB

Armstrong, W. N.:
Member

Baer, Ben: President, American National Bank, St. Paul
Member

Baer, Ed: Prominent St. Paul lawyer
Member

Baer, Frank:
Member

Baer, Ira: American National Bank executive, St. Paul
Member

Baylis, Kenneth:
Member

Becher, George:
Member

Bethume, R. A.:
Member

Bigelow, C. G.:
Member

Blakeley, William:
Member

Boardman, H. A.:
Member

Boyle, O. S.:
Member

Briggs, Allen:
Member 1920's - 1930's

Briggs, Isa: President, U.S. Chamber of Commerce
Member

Bryant, J. S.:
Member

Bunker, C. S.:
Member

Butler, Hunt:
Member

Clapp, William: Prominent St. Paul realtor
Member 1910's - Present

Clark, Kenneth: President, Merchants National Bank, St. Paul
Member 1920's - 1930's

Connelly, Dan:
Member

Corning, Leavitt: Prominent St. Paul leader and writer, founding father,
Member 1870's - 1910's

Corning, W.L.: 7th Ward Representative, St. Paul
Member 1870's - 1890's

Cutler, E. H.:
Member

Davidson, W.F.:
Member

Dawson, William:
Member

Dean, J. Dock:
Member

Denegre, James: Minnesota State Senator
Member 1880's - 1890's, President 1886

Drake, A. M.:
Member

Driscoll, A. B.:
Member

Evans, W. B.:
Member

Ellerbe, Thomas: Prominent St. Paul architect
Member 1910's - Present

Farwell, E. B.:
Member

Farington, W. C.:
Member

Finch, D. B.:
Member

Finchour, John: St. Paul Judge
Member 1920's

Flandrau, C. E.:
Member

Foster, H. G.:
Member

Fultun, J. F.:
Member

Gates, Fred:
Member

Gates, E. B.:
Member

Gilbert, Cass: Design architect of Minnesota State Capital
Member 1920's

Gordon, C. W.:
Member

Gotzian, P. H.:
Member

Granger, Warren:
Member

Gribben, Perry J.:
Member

Griggs, George:
Member

Ingersoll, F. G.:
Member

Jackson, J. N.:
Member

Jaggard, E. A.: Minnesota Supreme Court Justice
Member 1890's - 1910's, President 1893

James, H. C.:
Member

Jefferson, Charlie:
Member

Kennedy, R. C.:
Member

Kennedy, John A.: Famous Yale rowing coach
Coach 1890's - 1900's

Lang, :
Member

Langford, George:
Member

Langford, N. P.:
Member 1890's - 1920's, Coach 1910's, President

Lanpher, O. P.:
Member

Lawler, D. W.:
Member

Lightner, W. H.: Famous St. Paul lawyer
Member

Mairs, A. M.:
Member

Markoe, J. C.:
Member

Marvin, C. P.:
Member

McLaren, Archibald:
Member

Merriam, William R.: Governor of Minnesota
Member 1870's, President 1873

Mingaye, W. H.:
Member

Monfort, G. R.:
Member

Neilson, Paul: Prominent St. Paul contractor
President 1965 to 1978

Newport, L. E.:
Member

Noyes, Chas P.:
Member

O'Brien, Christopher D.: Mayor of St. Paul
Member

O'Brien, T. D.: St. Paul Judge
Member 1870's - 1880's

O'Leary, John J.:
Member

Ordway Sr., Lucius F.: National figure in rowing and yachting circles
Member 1920's - 1930's

Otis, James O.: St. Paul Judge
Member

Ozmun, E. T.:
Member

Paget, Lord Almerick H.: British Parliament
Member 1910's

Peet, W. F.:
Member

Parker, John:
Member

Parker, Percy:
Member

Ray, George: Famous Harvard rowing coach
Coach

Rice, Edmund:
Member

Rice, Sedgwick:
Member

Rugg, H. P.:
Member

Rundlet, L. W.:
Member

Savage, Arthur:
Captain and member 1910's - 1930's

Schurmeier, T. L.:
Member

Shepard, J. W.:
Member

Shepley, E. L.:
Member

Skinner, J. H.:
Member

Stewart, Robert:
Member 1890's

Stickney, S. L.:
Member

Tayler, James, K.:
Member

Towle,
Member

Twedt, Karl: Prominent St. Paul accountant
Member 1920's - Present President

Van Slyck, C. W.:
Member

Weatherby, Henry:
Member

Willis, J. W.:
Member

Wray, James:
Member

Wright, Cushing:
Member

Wright, Fredrick P.: Mayor of St. Paul
Member

Young, E. B.:
Member

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☆ U.S.GPO: 1982-564-052/1089-6

9 MAJOR BIBLIOGRAPHICAL REFERENCES

See attached sheets

10 GEOGRAPHICAL DATA

ACREAGE OF NOMINATED PROPERTY 51,000 ft^2 or 1.17 acres

UTM REFERENCES

A ZONE EASTING NORTHING B ZONE EASTING NORTHING

C D

VERBAL BOUNDARY DESCRIPTION

Upstream portion of Navy Island from Wabasha Street Bridge to tip of island.

LIST ALL STATES AND COUNTIES FOR PROPERTIES OVERLAPPING STATE OR COUNTY BOUNDARIES

STATE	CODE	COUNTY	CODE
STATE	CODE	COUNTY	CODE

11 FORM PREPARED BY

NAME / TITLE

DOUGLAS L. HOLMBERG, Civil Engineer

ORGANIZATION DATE

Member of Minnesota Boat Club, Employed by U.S. Army Corps of Engineers

STREET & NUMBER TELEPHONE

Apt #207, 1449 - 10th Street N.W. 725-7638

CITY OR TOWN STATE

New Brighton, Minnesota 55112

12 STATE HISTORIC PRESERVATION OFFICER CERTIFICATION

THE EVALUATED SIGNIFICANCE OF THIS PROPERTY WITHIN THE STATE IS:

NATIONAL ___ STATE ___ LOCAL ___

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665). I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service

[redacted] SIGNATURE

TITLE DATE

FOR NPS USE ONLY

I HEREBY CERTIFY THAT THIS PROPERTY IS INCLUDED IN THE NATIONAL REGISTER

DATE

DIRECTOR, OFFICE OF ARCHEOLOGY AND HISTORIC PRESERVATION

ATTEST: DATE

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